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SHELL FLOWERS.

ON a recent excursion to the seacoast of Brittany, we had an opportunity of observing a very pretty method of utilizing those thousands of brightly colored shells that the sea shapes and polishes in its incessant working of the sand. It is both curious and interesting to see with what art, with what truthfulness, the majority of the flowers of our gardens are thus imitated. The reproduction, in Fig. 1, of one of these little masterpieces of patience and observation shows plainly with what perfection nature is represented. Practiced in the first place in families, especially by little girls, this pleasing art, owing to the demands of bathers, has given rise to a sort of minor industry along our coasts. We have been pleased to study closely the manufacture of those flowerets, the brilliancy of which defies time, and it is the result of these observations of ours that we here record, happy if these few notes shall prove of utility to our lady readers.

The shells are employed only for forming the flower properly so called; all the green parts of the plant, such as stems, leaves, sepals, etc., are made of paper, according to the ordinary processes of florists, and are found ready made in the artificial flower trade. The tools are four in number (Fig. 2). They consist of a cutting nippers, 1, for cutting the wires of the stems, flat and half round smooth files, 2 and 3, for trimming and shaping the edge of the shells, a fine pincers, 4, for grasping the small shells, a cup of mucilage of gum arabic, to which is added enough powdered starch to give it the consistency of honey, a few boxes of prepared semoule, 5, that is to say, colored yellow or red for forming anthers, and, finally, an asortment of embossed leaves, tissue paper, iron wire, etc.

In most cases, the shells that are gathered on our beaches suffice for the manufacture of the flowers, particularly those whose corollas are white or yellow. For colored petals, it is necessary to have recourse to exotic shells, which are richer in varied shades than ours, and which, moreover, can be readily found at the stores of all the shell dealers of our large ports.

The varieties employed are relatively few in number, and we shall describe the principal of these in the course of this article. As a general thing, the shells are found in a rolled state, that is to say, already worn by friction on the sand and destitute of inhabitants. In this state, they have lost their sheen and have acquired a sort of velveting very favorable for a good imitation of flowers.

It is expedient to remark that each species of shell seems to have a preferred habitat. In the sandy strands of Saint Cast, we find the tooth shells; the barnacles in rocky bottoms; the periwinkles in places where certain algæ with long, thin filaments grow; the mussels on exposed rocks, etc.

One of the beings of the sea that furnishes the principal material of the floral industry is the barnacle (*Anativa lævis*, Lam.) This singular host of the ocean, which has the false aspect of a plant, has already been thoroughly described in this journal. The carapax comprises five pieces, of a beautiful milky white, two triangular shells which embrace the foot and protect the greater part of the animal, and two other and smaller shells hinged to the preceding, and having a very elongated triangular form. The double valves are united along one of the sides by a long narrow curved piece, the general form of which is that of a sickle. The shells are very light, and, in order to separate them without injury to their inhabitant, they must be placed in an earthen pan and allowed to enter into decomposition. In a few days, the operation having terminated, they are washed with an abundance of water, and the valves, which easily separate, are collected by means of pincers. They are then immersed in a solution of hypochlorite of lime in order to free the edges of the last traces of hinges. The valves are now adapted for making numerous flowerets. It will be always well, however, to round off the base of these triangular plates by means of a file, and to perfect the edges and give to the whole the form of the petals of the flowers to be made. The hooks serve for making chrysanthemums or the barbules of the honeysuckle (Fig. 2, *c*). The large valves are employed for camellias, eglantines, white pinks, white roses, and periwinkles, and the small ones for verbenas, the jasmin, the clematis and double daisies.

FIG. 1.—A BASKET OF SHELL FLOWERS.

Let us describe the manufacture of a camellia, which will serve as a type for the construction of all similar flowers, such as roses, etc. We take a wire of medium size and bend one extremity into the form of a loop, which, by means of gum, we fix to a cardboard disk of the size of a ten cent piece, and which we cover with a hemispherical layer of white wax, previously softened by kneading it with the fingers. Alongside of us we have, prepared, a series of petals cut out of the valves of the barnacle, and which we have taken care to classify in rows of increasing sizes. The first row, which will form the heart, comprises three small shells, the second, five, the third, nine, and so on; but, in order to give a proper conformation to the flower, care must be taken to alternate, by rows, the direction of the valves, by now taking those of the right and then those of the left. The point is dipped into the gum and the petals are inserted one by one in the wax support. The gum, on drying, fixes the petals very firmly.

The whole skill of the florist consists in selecting the proper shells, and in the insertion of the petals, avoiding too great a symmetry. The flower is formed with wonderful rapidity. The stem is covered with a thin layer of cotton to give it the desired thickness, and is then covered spirally with a strip of green tissue paper. The cardboard base is covered with green paper, cut so as to imitate sepals, then the leaves are affixed to the stems, and, if need be, there is added a little stem, to which is gummed a white cone, carved from cuttlefish bone, and provided with paper sepals. This forms the extremity, and the flower and its bud are finished.

The operation is the same for forming a chrysanthemum, but the petals here are imitated with the lances of the barnacle.

If the flower possesses a disk, as in the daisy or the aster, there is employed either a colored cardboard center such as may be found in the shops, or one that may be easily made by kneading a little bread into the desired form upon a brass wire hook. This is covered with gum and then dipped into the fine semoule and colored yellow with a little saffron or turmeric. The narrow valves of the barnacle shaped with a file are to be gummed beneath the disk, and will form the ray flowers (Fig. 2, A). The whole is consolidated with green paper, cut to resemble bracts.

The manufacture of China asters will put the patience of the florist to a severe test. Flowers of this kind have been shown to us that were scarcely as large as a fifty cent piece, and which yet contained nearly a thousand of these little shell plates.

In order to form centers with projecting stamens, it is necessary to use a pencil of silk threads stiffened by gum, and the point of which, passed over starch paste, is sprinkled with grains of semoule made yellow with saffron or red with carmine.

Another kind of shell much employed is the tooth shell (*Dentalium tarentinum*, Lam., Fig. 2, *d*). This is a sort of conical, slightly bent tube, of a pure white or ring-streaked with yellow, which is usually found only in a rolled state.

The tubes serve for the manufacture of all those flowers whose corolla expands at the extremity of an elongated calyx, such as the fuchsia, the honeysuckle, the primrose, the jasmin, etc.

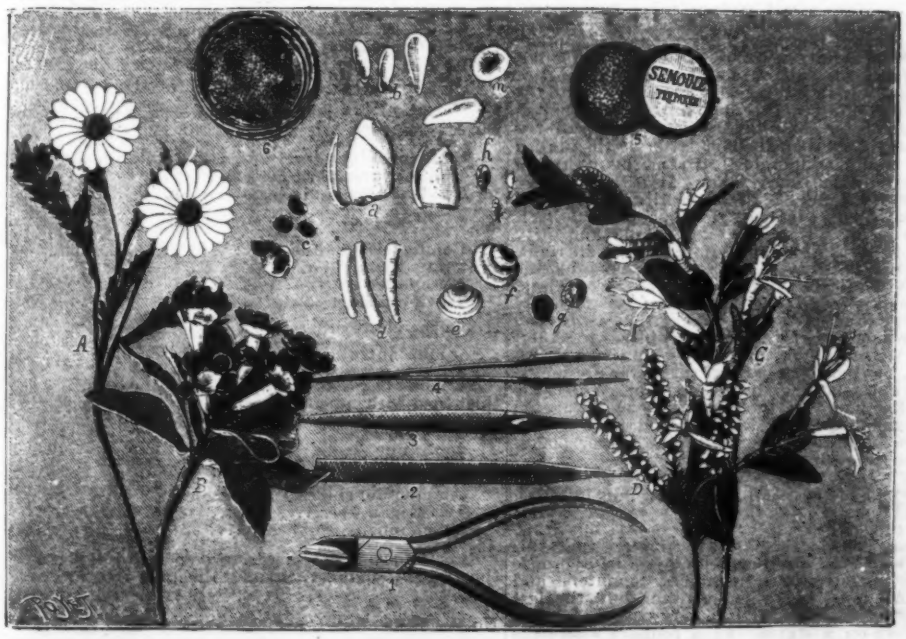


FIG. 2.—TOOLS FOR MAKING SHELL FLOWERS.

1. Cutting nippers. 2 and 3. Files. 4. Pincers. 5. Prepared semoule. 6. Starch paste.—Shells: *a*, carapax of barnacle; *b*, valves of barnacle filed into the form of petals; *c*, operculum of periwinkle; *d*, tooth shells; *e*, Tellissa baltica; *f*, Strigilla; *g*, Parilla; *h*, Nassa incrustata; *i*, Rissoia lactea; *m*, Calyptræa. Flowers: A, aster made of barnacle shells; B, bear's ear of tooth shells and opercula of the periwinkle; C, honeysuckle; D, heaths.

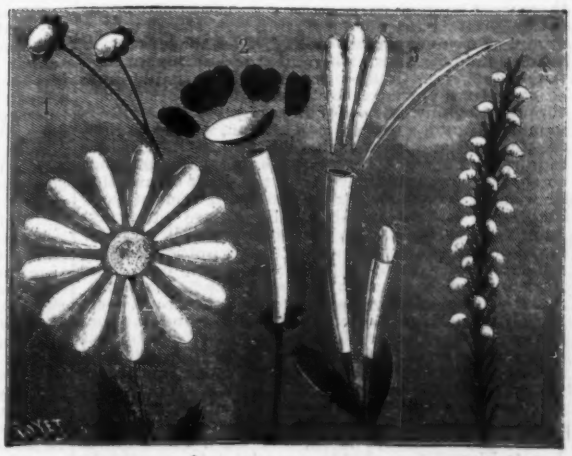


FIG. 3.—METHOD OF MANUFACTURING VARIOUS SHELL FLOWERS.

1. Field daisy (filed barnacle shells) and bud (sea snail). 2. Bear's ear (tooth shell, Calyptræa and operculum of periwinkle). 3. Honeysuckle (tooth shell and small valves and lance of barnacle). 4. Heath (silk fringe and rissoias).

Under the name of bear's ear, we find upon the cliffs a small primrose with a brown corolla and white calyx, which is quite easily imitated. A small white tooth-shell will furnish the slender calyx. To the top of this is gummed, flatwise, a white shell in the form of a widened funnel (*Calyptræa*, Fig. 2, *m*), and to the edges of this are fixed in pairs those small brown opercula which close the orifice of the periwinkle.

Small mussel shells with pretty violet tints, after having been carefully freed from all animal integuments by an immersion in hypochlorite of lime, will serve for making Canterbury bells, scabiouses, violets, and forget-me-nots, even. The spines of the sea urchin, according to their color, are employed for blue-bottles, resedas, scabiouses, etc.

Commerce furnishes silk ribbons woven in the form of flat fringelets of a bronze green color. These being wound spirally upon a wire, at once give the illusion of sprays of heather (Fig. 2, D). These sprays are provided with flowers by gumming to the extremities of the fringelets small white or violet spiral shells that are found in abundance in the sand.

Univalve shells, such as the limpets (*Patella Tastei*, Fig. 2, *g*), having a wide conical form, or bivalves, such as the tellens (*Tellina Baltica*, Fig. 2, *e*), and even debris of all sorts, of a rose color, pale yellow and violet, are utilized, after being filed, for imitating the smallest parts of flowers, while the spiral univalve shells (*Nassa incrustata*, Fig. 2, *h*, *Nevites*, etc.) form the majority of buds. In order to imitate colored flowers the shells may be stained with water colors dissolved in mucilage, but it will be better for this purpose to employ exotic shells, among others of which we may mention one that comes from the Antilles, and that is of a dark rose color of the most charming effect (*Strigilla carnaria*, Fig. 2, *f*). This is a bivalve having some resemblance in form to the cockles. The valves form the petals of roses, eglantines, etc. Fig. 3 shows the method of manufacturing various flowers, such as daisies, heath, etc. In the course of our inquiry we have had shown to us a process of decorating white shells that merits special mention. It concerns the imitation of the rosy rimlets that are observed at the base of the petals of certain geraniums. The skillful florist, for this purpose, used one of those pretty seaweeds (*Plocamium vulgare*) of a beautiful dark rose color that are found on the rocky shores of the Channel. Spread out upon the white valves of the barnacle and fixed with a little gum water, the delicate sprays of the alga perfectly imitate the network of the plant. The specimens that were shown to us had been prepared before the war of 1870, and were so bright in color that one would have said that they had just been finished.—*La Nature.*

HOW STATUES ARE MADE.

IN painting, mechanical dexterity is quite a minor matter, and the painter is comparatively free from any but artistic considerations. In sculpture, on the other hand, though the same application of artistic principles is exacted and necessary, a large proportion of purely mechanical work falls to the share of the artist, necessitating unusual care and skill.

A painting practically passes through only two, or at most three, stages in the course of its development into completed form; there are the sketches, the studies and finally the finished painting. In sculpture the case is somewhat different. There we have also preliminary studies and sketches, but the clay model already shows the work in its artistic completion. The plaster cast is simply a reproduction of the model in clay, and is in turn reproduced in marble or bronze. Thus when the statue is practically finished, it must still pass through two more stages, in which usually nothing is added to the original work (except sometimes in the plaster cast), but it is simply reproduced in other materials. But this process involves no end of labor and anxiety.

The sculptor begins by giving form to his idea in a small model from four to six inches in height. This is a mere sketch, roughly blocked out, but it suffices to give an idea of the position of the proposed figure, or the composition of the group if there are several figures. The material used in this first study is sometimes modeling wax, but usually clay or plastiline. The latter, a kind of wax, somewhat resembles putty, but does not harden; unlike clay, therefore, it does not need to be wetted.

From this preliminary sketch the artist usually prepares a larger study, generally in clay, and say about one foot in height. This is already very much more elaborate than the first, and allows the intent and conception of the sculptor to be seen much more clearly. From these smaller models, which have been wrought over into a suggestive semblance of the work to be, there must be evolved a large clay model of the size in which it is intended to reproduce the figure or group. But such a mass of clay, if left unsupported, would collapse. Even with the precautions that are taken, dangerous break-downs have occurred in large or equestrian groups. But these would occur only through the inexperience of the sculptor. The clay is moulded around a sort of iron skeleton, with lead pipes for the arms and legs, which are bent into the positions required. This model is placed on a revolving stand, so that the sculptor may have the light on any side he wishes. The modeling is done with tools of bone and wood of various sizes. Some are about the length and thickness of a carpenter's pencil, and flattened out at one end or at both ends; others have a triangular wire loop projecting from one end. The finer touches are often put in with the fingers alone, and it is interesting to watch the artist at work, picking off a small lump of clay at one place and dabbing it on in another, or producing delicate effects by deft digs or sweeps with his thumb. Water is occasionally squirted upon the model to keep it moist, and when the day's work is done the figure, after another sprinkling from the hose, is covered with damp cloths.

In this clay model the figure is worked out completely to the smallest detail, and when the sculptor has fashioned the pliable material into exactly the shape that he wants, the whole is cast into plaster of Paris. A plan followed by some sculptors is to have the plaster cast made before they have finished modeling; in that case the work is completed on the plaster cast, as good plaster can be prepared for this purpose. Hiram Powers is said to have done all his modeling in plaster, and invented some very ingenious tools for this work. Ward, I am told, when making the equestrian statue of General Thomas, first prepared a careful study of the horse, about one-third of the proposed size. From this, by exact measurements, he manufactured a sort of skeleton three times as large, with ribs, which he covered with burlaps. Then he piled on the plaster, being guided all the while by measurements made from all points of the small models. It was a very ingenious way of avoiding the difficulties presented by the tendency of the legs of large animal figures to crack and crumble when modeled in clay.

The next and last step is to reproduce the plaster cast in the material in which it is desired to perpetuate the artist's work. Marble or bronze is generally used for this purpose, and whether the statuary is hewn out of stone or cast in metal the operation in both cases is a delicate one and requires a high degree of mechanical and artistic skill.

If the material chosen is marble, the process is as follows: The material is placed upon a large "scale stone," and the marble block on a similar one. Marks are then made on all the projecting or salient parts of the plaster figure, and each "scale stone" is also covered on its front with a number of points, which are the same on each stone. By means of an ingenious contrivance the marble is drilled full of holes corresponding to the marks made on the model. The instrument used for this purpose is what is known as a "pointing machine," which is provided with arms that end in metal "needles," and which is placed between the two "scale stones." In using it, one of the arms, which move in ball-and-socket joints, is set to touch a point on the scale stone, while the upper one is pointed upon a mark on the figure. The arms are then fixed in this position by means of a screw, and the instrument is swung around to the other scale stone. Here a corresponding point is touched by the lower needle, while the upper one, of course, strikes upon the marble block. This upper needle is made to slide backward and at the point it marks a hole is drilled into the marble. The hole is continued to such a depth that when the needle is protruded again to its full length and touches the bottom of the hole it marks a spot that corresponds exactly to the place on which it was set on the plaster cast. This operation is repeated until the marble is covered with a large number of holes. The "scarpellino," or chiselman, then cuts away the marble as far as the bottom of all the holes. After the statue is thus roughly blocked out it passes into the hands of a more skillful scarpellino. The latter completes the marble statue almost entirely, being constantly aided by the pointing machine in making measurements. The sculptor then has little to do more than to add the finishing touches.

In Greek and Roman times, and among mediæval artists, the nude figures, it seems, were given a great degree of polish, to suggest the glossiness of the skin; nowadays a grain is usually left on the marble. Michael Angelo, it is said, occasionally cut his statues out of the marble without first making a model, but this is a feat which requires a marvelous degree of skill. The late William Rimmer, of Boston, the famous authority of art anatomy, performed a similar task when he carved a colossal head of St. Stephen directly from granite without a model.

Various sculptors of the middle ages, like Michael Angelo, when working in marble, did much of the work themselves, while many modern artists leave a large part to be done by assistants. Some, also, after having defined their conception of a figure (especially accessory figures in groups), and decided upon the pose, composition and other matters, leave even the modeling to be carried on to a great extent by expert assistants, who often have had an excellent artistic training. The sculptor afterward goes over the work, completes it, adds the finishing touches, and infuses into the whole the feeling of his own artistic individuality and style.

Now, suppose the sculptor's work is to be cast in bronze; the process is a difficult and delicate one and demands great care and skill. The first step in the operation is to make a sand mould from the plaster cast, the sand for which is brought from Fontenoy-aux-Roses, a place about sixteen miles from Paris. The plaster is first coated with shellac, over which "talk," the dust of potatoes, finely ground, is applied, before the sand is put on. There are really two moulds the inside one, or "core," and the outside one, or mould proper, which is lined with plumbago. Into the space between the two the molten metal is poured. Here it remains for from two to four days until the metal is completely cooled. The latter is then taken out of the mould and cleaned of sand by means of brushes and tools of hard wood. It is then dipped into acid, which takes off all impurities and gives it the gold-like color of bronze. The operation, in fact, is the same as if you were cleaning an old and dirty copper cent. If the casting is found to be all right, it is then turned over to the chaser, who takes off the seams. He follows the plaster model instead of riffling the bronze into a polished surface, as was formerly done, and as in fact is done by many to-day. It then goes to the mounter, who joins the pieces together. Across the water this joint is made within one-eighth of an inch, but here, the parts of the statue are joined to within one sixty-fourth of an inch. When the statue is thus mounted, the chaser goes over it again; it is then examined by the sculptor, and if any slight changes are found to be necessary, the chaser makes them under the sculptor's eyes.

Formerly all bronze statues that were to be set up in this country had to be cast in Europe, usually in Rome, Munich or Paris. To-day the whole work can be done right here under the sculptor's supervision; but it is, in fact, only within the last fifteen years that this has been so. The workmen employed in a bronze foundry comprise porters, moulders, mounters and chasers. All must be skilled artisans, but the last must really be artists. Only the very best chasers can be set to work on a statue. In a foundry where the work is very carefully done, less monumental work is produced than might be supposed.—*New York Times.*

To make an ink from which a copy can be taken, by using the copying paper simply as though it were blotting paper, *i. e.*, no press, no wetting, use aniline ink containing a large proportion of glycerine.

A TWO-BOTTLE MARKING INK.

By R. WRIGHT.

THERE appears to be a demand for a marking ink in two bottles, and judging from the fact that questions have frequently been asked in the "correspondence" columns of this journal as to the composition and method of preparation of such inks, the subject is one not wholly destitute of practical interest to retail members of the drug trade. The fact that the formulæ which have been published from time to time have not yielded in my hands good results, and that others have proved more reliable, must be my apology, if such be needed, for troubling you with this note.

In *The Chemist and Druggist* for November 26, 1887, the following formulæ were given:

No. 1. Solution.

Chloride of copper (in crystals)...	8·52	grains.
" sodium.....	10·65	"
" ammonium.....	5·35	"
Water.....	1 fl.	drachm.

Dissolve.

No. 2 Solution.

Hydrochlorate of aniline.....	20	grains.
Distilled water.....	30	minims.
Mucilage of acacia.....	20	"
Glycerine.....	10	"

Dissolve.

For use as a marking ink, 4 drops of No. 2 solution are mixed with 1 drop of No. 1.

In *The Chemist and Druggist* for April 30, 1887, the following formula was recommended:

	Drachms.
Crawshaw's black dye	1
Acetic acid.....	1
Rectified spirit.....	1
Water.....	4

Digest the dye in the mixed liquids at a gentle heat till dissolved, then add 4 fluid drachms of glycerine and mix. Serves as a marking ink on the addition of a mordant.

In the course of some experiments made with a view of discovering a reliable method, the above mentioned recipes were tried, but the results were not very encouraging. The first mentioned solution, when mixed, gives an ink which is not nearly thick enough to write with, and as a result, it has a tendency to run. Another disadvantage is that the writing is almost colorless when freshly done, and it is sometimes very difficult to trace the marks. On exposure to the air it becomes considerably darker, but seldom, if ever, yields a jet black, even on long exposure and subsequent boiling with soap lye. With the second formula the results were just as unsatisfactory: once or twice boiling with soap had the effect of almost entirely obliterating the marks. From this it was evident that some other process would have to be adopted in order to secure anything like good results.

In Cooley's "Cyclopedia," page 1626, in an article on "Tar Colors," the following recipes are given for the production of aniline black.

1. Dissolve 20 parts of potassium chlorate, 40 parts of cupric sulphate, and 16 parts of ammonium chloride in 50 parts of water, warming the liquid to about 60°, and then remove it from the water bath. In about three minutes the solution froths up and gives off vapors which strongly attack the breathing organs. If the mass does not become black after the lapse of a few hours it is again heated to 60°, and then exposed in an open place for a day or two, and afterward carefully washed out until no salts are found in the filtrate. For use in printing the black paste is mixed with a somewhat large quantity of albumen, and the goods after printing are strongly steamed.

2. Mix equal weights of aniline (containing toluidine), hydrochloric acid, and potassium chlorate, with a minute quantity of copper chloride and a sufficient quantity of water, and leave the mixture to evaporate spontaneously, when a black powder will be obtained.

From this it is evident that an aniline black may be obtained, by the action of an oxidizing agent upon aniline or aniline chloride in presence of a copper salt; and it was thought possible, by a rearrangement of the ingredients in the above processes, to produce two solutions which, when mixed, would be capable of giving rise to the production of the same color. With this object in view, the following solutions were prepared:

No. 1. Take of—

Commercial aniline.....	1	fluid drachm.
Dilute hydrochloric acid, B. P.	2	" "
Thick mucilage of acacia.....	1	" "

No. 2. Take of—

Commercial aniline.....	1	fluid drachm.
Dilute hydrochloric acid, B. P.	2	" "
Methylated spirit	1	" "
Thick mucilage of acacia.....	1	" "

Mix in the above order.

For mordants the following solutions were tried:

No. 1. *Chemist and Druggist* formula given above, thickened with mucilage.

No. 2. Take of—

Potassium chlorate.....	30	grains.
Cupric sulphate.....	40	"
Ammonium chloride.....	30	"
Distilled water.....	6	fluid drachms.
Thick mucilage of acacia....	2	" "

Rub the solid ingredients to powder, to dissolve in the water (boiling), then add the gum solution, and mix.

No. 3. Take of—

Copper chloride.....	40	grains.
Sodium chloride.....	30	"
Ammonium chloride.....	20	"
Potassium chlorate.....	20	"
Distilled water.....	5	fluid drachms.
Thick mucilage of acacia....	3	" "

Dissolve the solid ingredients in the water, previously

heated to the boiling point; add the mucilage, and mix.

Each of the aniline solutions was tried with the three mordants, with fairly satisfactory results. The aniline solution without spirit seemed to promise best, and certainly gives an indelible black with Nos. 2 and 3 copper solutions.

It occurred to me that possibly the aniline might be improved by the addition of a little toluidine, and one or two experiments were tried with the addition of the solid orthotoluidine. The following solutions were made:

No. 1. Take of—

Aniline	1 fluid drachm.
Toluidine	10 grains.
Dilute hydrochloric acid, B. P.	2 fluid drachms.
Mucilage of acacia	2 " "

Dissolve the toluidine in the aniline, add the acid and the mucilage, and mix.

No. 2. Like No. 1, with the addition of 1 fluid drachm methylated spirit.

Both these solutions give good results with mordants Nos. 2 and 3; the marking is clear and distinct, and turns perfectly black when boiled with soap lye. No. 1 solution of aniline and toluidine, with No. 3 mordant, yields probably the best ink. A quill pen should always be used with inks of this character, and the goods, after being marked, should be left for a day or two before being washed, in order to give time for the chemical reaction which results in the production of the aniline black to take place.

I have by me now samples of linen which were marked with an ink of this character over three years ago, and which have repeatedly been boiled with a strong soap solution since then, and the marking is as distinct to-day as when first written. One of these specimens I inclose for your inspection.

[The results seem to us to be excellent. Mr. Wright has done a useful piece of work in these experiments. —ED. *Chemist and Druggist.*]

THE SOURCES AND APPLICATIONS OF BORAX.*

By E. L. FLEMING.

BORAX is a white, crystalline substance, peculiar to the mineral kingdom; it is a very mild alkali, of a pleasant sweetish taste, and is not injurious to the human system; it is freely soluble in water; its solution acts as a solvent for resins, albumens, fatty acids, and certain organic bodies that are not soluble in water alone; but it does not appear to attack fibers, membranes, tissue, or skin. In the crystalline state or in solution, it is very easily decomposed by such acids as tartaric acid or acetic acid; but in its calcined or anhydrous state, when fused, the boracic acid it contains acts as a more powerful acid than even sulphuric acid. Borax in the crystalline state contains 47¼ per cent. of its weight of water, to which it tenaciously adheres at the ordinary temperature of the atmosphere, time seeming to have very little effect upon its character. At the boiling point of water it slowly parts with nearly the whole of this water, and if the process be conducted quickly, at a still higher temperature, the borax swells to several times its size, becoming a body of a light and porous nature, which may be crushed to a compact powder. At a higher temperature than 450° Fahr. it melts to a clear glass, which remains transparent on cooling. Though the applications of borax are not generally known, as a fact this interesting and valuable salt will be seen to be utilized in different ways by several industries, which are so numerous and important that it may be convenient to group them under different heads, and again specify the classes of each group. These groups may be considered under the heads of hardware, earthenware, chemicals, textiles, leather, and food.

In order to demonstrate the application of borax under each group, various representative firms have very kindly furnished specimens, in order to show the way in which it is used in their particular industry, and these specimens are now displayed on the table before you. It must not be taken for granted that every one in each particular trade uses borax. I only mention this to avoid being misunderstood. In the hardware industries it is used by goldsmiths, coppersmiths, ironworkers, safemakers, machinists, and metallurgists. For goldsmiths a special grade of borax is prepared, called jeweler's borax, in pieces as solid and free from cracks as possible, so that when rubbed on a slate with water it is not liable to fall to pieces, but will gradually wear away until too small to handle conveniently, when the small pieces are put on one side, to be used as a flux in melting or collecting. The manner in which borax is used in soldering gold work is as follows: A piece of borax is rubbed on a slab of slate with a small quantity of water until a rather creamy mixture results, and parts of the work are dipped in this, and the small pieces of solder applied by the aid of a camel's hair pencil moistened in the solution. The solder is then caused to melt by a quick blast from a blow pipe.

In brazing copper it is used for cleansing the parts to be joined, on account of the property it possesses of dissolving the oxides that form a film upon the metal. It is very extensively used in the manufacture of copper pipes and for other purposes.

In welding iron and steel together it answers the same purpose. Machinists and others use the crystal for chilling the iron to the right temperature, for the purpose of casehardening or tempering different portions of machinery or implements to the desired degree.

An enameled coating for cast iron and steel as well as copper is made by fusing on the metal a mixture of quartz, feldspar, clay, and borax, and then covering it with a glaze containing borax. It is thus extensively used in the manufacture of enameled iron mantelpieces, made to represent the rarest marbles, and in the great variety of enameled signs and hollow ware. Borax is also used in conjunction with infusorial earth for lining fireproof safes, for being a salt that contains nearly fifty per cent. of its weight of water of crystallization, with which it parts at a high temperature in the event of fire, the steam arising from the heated borax permeates the books and papers in the safe, and prevents their being burnt. For this purpose it is superior to alum, which is an acid salt, and has a tendency to corrode the iron. At a red heat the boracic acid in borax readily dissolves, and unites with metallic oxides, forming a fusible glass, which property renders borax of great use in conjunction with other fluxes, for certain mineral and metallurgical processes.

In the earthenware industries it is used by manufacturers of imitation gems, glass, china, earthenware, and cement. In the manufacture of "strass," which is the base of artificial gems, borax is mixed with pure silex, potash, and white lead, put into a Hessian crucible and kept at the highest heat of a pottery furnace for twenty-four hours. The longer it is kept in a state of fusion, the clearer and more homogeneous it will be when cooled. For colored gems various metallic oxides are added, in proportions only learned by experience. The coloring matter must be in the finest powder, and not only very intimately mixed, but the mixture must be very strongly heated, the heat must be long continued and the cooling gradual. In the manufacture of glass it is not a necessary ingredient, but when used it is the strongest flux known.

In the specimen before us it is contained in both the opal and flint metals. In the brilliant yellow glass of Sevres it forms over 10 per cent. of the component parts. It is used for staining glass different colors.

Borax has recently been applied with considerable success to the manufacture of optical glass at Jena. This glass has very high refractive properties, and has been very successfully applied to the manufacture of lenses for microscopes and for photography.

Borax is now used in glazing china and earthenware so extensively all over the world that the consumption in these industries, at the present time, exceeds any of the others. The principle adopted is to form a fusible glass of borax and other materials, and fuse it on to the baked earthenware. Many formulas have been published of the composition of this fret, but almost every large firm have their own formula.

In the manufacture of Parian cement the borax is added for the purpose of enabling the cement, when set and moulded, to take a polish.

In the chemical industries, it is used in the manufacture of soap, colors, drysaltery, and cosmetics; also in photography and timber preserving.

There are many kinds of borax soap. From all accounts its use in this industry arose from the fact that the linen of Holland and Belgium became celebrated on account of its superior whiteness, in the cleansing of which borax was used as a soap powder; and hence we find that dry soap, soft soap, and toilet soaps are now made with it.

In the manufacture of colors borax is used, in the preparation of borate of chromium, a pale green powder, and borate of copper, a darker green. These are used as substitutes for arsenical green in painting and dyeing.

In drysaltery it is used in the shape of borate of lead and borate of manganese. Both these products are used in the manufacture of varnish (as driers). The borate of lead is used for the palest varnishes, and the borate of manganese in other varnishes.

As a cosmetic, it enters into the composition of many preparations for the hair, the face, and the hands.

Photographers use it in the toning bath to govern the action of chloride of gold, which is dissolved in conjunction with it, for changing the color of a photographic print from the first or red color to a beautiful brown or black. It is also used as a water varnish to give a gloss to collotype prints. Also in the Woodbury printing process, a sheet of paper for printing on is first rubbed all over on one side with a solution of borax, and then floated on a solution of shellac; when dried it is ready for printing on.

In the preservation of timber it is used for dissolving the albuminous resinous matter, or the sap, which readily decays, leaving only the tough fiber.

Borax dissolves caseine, forming a substance which can be used as mucilage.

In the textile industries it is used in the manufacture of silk, calico, lace, hats, candle wicks, linen, and paper.

In silk it serves for dissolving the glutinous matter adhering to raw silk.

In calico printing it is used for fixing certain colors as a mordant.

Laces, muslin, tulle, and other light fabrics steeped in a solution of borax are rendered fireproof.

Hat manufacturers use borax for dissolving shellac to form a stiffening for felt hats made of wool. A weak solution of borax is used after the felt body is proofed, to wash from the surface any excess of stiffening not required upon the face of the felt.

Candle wicks are prepared with a solution of borax. Its use is to cause the wick to curve in burning, and at the same time to vitrify the ash. It also prevents the wicks from burning too rapidly, and obviates the necessity for snuffers.

In starching linen it acts as an economizer of starch, giving a clearness and stiffness as well as a glaze to the goods.

In the manufacture of paper and cards it is also used in glazing. To obtain this glazed finish, a solution of shellac and borax is floated over the surface, which is afterward subjected to very heavy pressure.

In the leather industries it is used in curing and preparing skins, by leather dressers and leather dyers. This sheepskin rug has been sent by a manufacturer, who states that borax was used among other ingredients in preparing it.

It is used as a mordant in dyeing leather with aniline colors. And also in polishing, a little borax in the blacking or color is added to enable the iron used in polishing to pass freely over the leather. It prevents the iron sticking and increases the glaze.

In the food industries it is used by pork packers, fish curers, grocers, glacialine manufacturers, and druggists.

Pork packers use powdered borax for sprinkling over hams and bacon. Thousands of tons of meat are thus annually preserved in America.

Fish curers use a mixture of boracic acid, alum, and salt for keeping herrings fresh. The principal seat of this industry, so far, has been at Hangoesund, near Stavanger, in Norway.

Grocers supply borax for culinary purposes, and glacialine manufacturers use borax in their preparations for keeping milk.

Druggists use it in the preparation of at least a dozen drugs, such as borax lozenges, borax pastilles, and *mel boracis*, or borax and honey.

Having thus practically demonstrated its usefulness, let us turn our attention to the sources from whence it comes. England has no borax fields or mines, and at present the material, either in the manufactured state or that from which it can be manufactured, comes from Thibet, Italy, Chili, California, and Asia Minor. Thibet is the most ancient source, and under the name of "tincal" borax is brought from the neighborhood of Yam-dokcho to Calcutta, from which port the source of origin is distant between 400 and 500 miles almost direct north. At the present time there is railroad communication as far as Darjeeling, or a distance of 300 miles.

There is also a borax refinery at Jagadhri, 37 miles southeast of Umballa, in Northern India. All the borax which is exported from India is brought from the Trans-Himalayan region.

Stretching from Ladak, or Leh, eastward as far as Lhasa, along the course of the Sutlej and Brahmaputra, are a line of lakes about a thousand miles in length, and it is from this district that the tincal comes. The deposits of borax are invariably associated with sulphates and carbonate of soda, with more or less chloride of sodium and earthy matters, from which the tincal is mechanically separated by the natives, and packed in small woolen bags, holding 25 lb. to 30 lb. each. It is transported across the mountains to the highways of commerce upon the backs of sheep.

The supply from this source has never been very extensive, owing to climatic influences, the difficulties of transport and the competition from other sources. According to the official returns, it appears that, in 1883, 1,201 tons were exported from India, while in 1887 only 714 tons were exported. The quality of the tincal varies from 65 per cent. to 90 per cent. of pure borax.

The Italian source of borax is crude boracic acid, the development of which, by the grandfather of the present Count Larderel in the year 1818, is a matter of history. The boracic acid springs are situated in the Pomarance district of the province of Pisa, sixty-five miles southeast from Leghorn.

In the volcanic districts in Tuscany there are many places where jets of steam are thrown up which are charged with boracic acid. These are known as *soffioni*. The steam is condensed by being passed through water in basins. The water is evaporated by the heat of the *soffioni* and the acid thus obtained. Between 500 and 600 people are engaged in the industry, and it is stated that the expense of producing a ton of boracic acid of commerce amounts to £15.

The average composition of the crude material, taken from samples of 5,000 tons over three years, shows it to consist of 83½ per cent. of pure crystallized boracic acid, which is equivalent to 128½ per cent. of borax; that is to say, with the addition of soda and water, 100 parts of crude Italian boracic acid will produce 128½ parts of borax.

From the Board of Trade returns, the production of boracic acid in Italy, for three years 1884–86, showed an average of 2,445 tons per annum, which, converted into borax, would be 3,141 tons. Efforts have been made from time to time to increase the supply of boracic acid, without success.

There is railroad communication to within about eight miles of the works. The acid, packed in large casks weighing 13 cwt., is hauled to the railroad station on two-wheeled carts drawn by a mule or pony, two casks, and sometimes only one, forming a load. In the distance these ponies with their loads winding round the country roads look like ants carrying a grain of corn.

In the year 1836, a double borate of lime and soda was found near Iquique in Peru. It is a silky, fibrous substance, which looks very much like asbestos. It was identified by Ulex, after whom it has been called "ulexite." When pure, it is capable of yielding a very large percentage of borax, but it is generally associated with sulphate of lime, sulphate of soda, and common salt. It is found in nodules, from the size of a hazel nut to a large pumpkin, embedded in the marsh or lagoon, under an upper crust of sand and salt varying in thickness of from one to five inches. Large quantities of this borate of lime have been shipped from Iquique, Antofagasta, and Caldera.

The borate, when first dug out of the marsh, is rather moist, and the lumps are left lying exposed to the sun's action to dry. Mr. Robottom, who has just returned from Chili, states that the largest deposits of borate of lime are situated at Ascotan, in the province of Potosi, Bolivia, latitude 21° S., longitude 68° W. There is a railroad running past the deposit down to Antofagasta, a distance of 300 miles, the freight to point of shipment being 25s. per ton. The Ascotan lagoon is 12,000 feet above the sea level, it is 25 miles long, with an average width of from three to six miles.

The borate is made into borax and boracic acid at Antofagasta, where there is a large and well regulated works.

About 50 miles southeast of Iquique, 14 miles from Pica, at the foot of the Pintadas mountains, there is another deposit of borate. There is also a deposit at Maricunga, to the north of Copiapo, the shipping point for which is Caldera.

The raw material contains, on the average, 25 per cent. of boracic acid, equivalent to 66 per cent. of borax.

The annual production of borate of lime in Chili and Bolivia is estimated at 4,500 tons, equivalent to 3,000 tons of borax.

The Californian source, with which is associated Nevada and Oregon, is probably the most prolific in borax minerals of any section of the globe. Whatever you find in other borax-producing countries you find here, viz., tincal, boracic acid, double borate of lime and soda, and sesquiborate of lime. Borax was first discovered in California in the year 1856, by Dr. John A. Veatch.

Of tincal, or crude borax, there are no less than ten deposits, or borax marshes, as they are called. Five of these are situated in California and five in the neighboring State of Nevada.

The Californian marshes are situated at Saline Valley, Furnace Creek, and Armagosa, all in the County of Inyo; Slate Range, in San Bernardino County; and Lower Lake, in Lake County. The Nevada marshes are at Rhodes, Teel's Marsh, Fish Lake, and Columbus, in the County of Esmeralda, and Salt Wells, in Churchill County.

* A paper recently read before the Society of Arts, London.

Besides these borax deposits, there are deposits of double borate of lime at Rhodes and Columbus, in Nevada, and Death Valley, in California. And also mines of sesquiborate of lime at Dagget, in San Bernardino County, at Death Valley, in Inyo County, California, and at Chetco, in Oregon.

The general view of a borax marsh is perhaps best illustrated by a photograph, and, for this purpose, we we will throw on the screen a photograph of the Saline Valley borax marsh.

This marsh, which is one of the richest in the State of California, is situated on the eastern slope of the Sierra Nevada mountains, 11 miles from the line of the Carson and Colorado Railroad, and 220 miles east of San Francisco; the valley is 18 miles long by 12 miles wide. The crude borax covers the plain to the extent of over a thousand acres, with a depth of from 6 inches to 18 inches.

The borax is mixed with sand, sulphate of soda, carbonate of soda and salt. The color of the crude material, as it lies upon the plain, is of a peculiar grayish yellow, giving the surface the appearance of snow, somewhat tinged by age. The material varies in richness from 10 to 90 per cent. of pure borax.

The next photograph will show the crude method adopted in refining the borax. The plant consists of long semicircular iron pans, into which the material is thrown, the pans are boiled by fires underneath, and when the solution is of the required strength, after settling for a few hours to allow the solid matters to subside, the clear liquor is run off into vats to crystallize, which takes about a week; and the crystallization being complete, the mother liquors are decanted, and the borax removed and packed.

The process is so simple that Indians are employed in borax refining. The next two photographs will show groups of these natives; they belong to the Pah Ute tribe, and very good fellows they are; they are paid a dollar a day.*

The cost of obtaining a ton of borax at the marsh amounts to £3 10s., in addition to which there is hauling and railroad, and freight to the market.

The Death Valley borax marsh lies a little to the southeast of Saline Valley, and more remote from the railroad. Death Valley takes its name from the circumstance of a company of emigrants entering it, on their way from Salt Lake to California, in the year 1850. Very little was known then of the passes through the mountains, and this party made the fatal mistake of attempting a more direct pass than that by the well known emigrant road. The valley was to them a *cul de sac*. While seeking an outlet, they experienced dangers and difficulties altogether unexpected and almost insurmountable. Finding it impossible to take their wagons over the mountains, they abandoned them, and while some of the party climbed the rugged and roadless passes, others, seeking water, miserably perished.

In this valley, and also at Calico in San Bernardino, there exist mines of sesquiborate of lime, or borate spar. This borate lies in ledges varying in thickness from 6 inches to 6 or 7 feet, and crops out at the surface at different angles.

The photographs now exhibited on the screen will best explain the manner in which this borate occurs.

The borate is mined in the ordinary manner by sinking shafts and running levels.

The material is carefully picked and freed from the limestone, gypsum, and steatite with which it is associated, when it yields a product containing from 35 per cent. to 40 per cent. boracic acid, and can be converted into its own weight of borax.

There are three kinds of sesquiborats of lime that correspond to the three varieties of carbonate of lime, viz., calc spar, marble and chalk. In many instances it is extremely difficult to distinguish by the eye the difference between the borate and the carbonate.

Prospectors for borax and borates frequently use a little sulphuric acid and alcohol to detect their presence; the boracic acid liberated by the acid gives with alcohol, upon ignition, a beautiful green flame. If you have no means of obtaining these, a little vinegar and whisky will give the same result.

These three varieties of sesquiborate of lime are worked in Oregon, California and Asia Minor.

At Chetco, Oregon, the borate of lime occurs in large, beautifully white nodules, embedded in a soft serpentine formation. This variety is similar to chalk.

The borate spar of California is similar to calc spar, and the boracite of Asia Minor may be likened to marble.

At the present time, the production of borax on the Pacific coast amounts to 6,000 tons per annum, most, if not all, of which is consumed within the limits of the United States.

The next and last source is that from Asia Minor. Boracite, as it is called, was discovered in 1869 at Sultan Chairi, near Suzurlu, in Asia Minor, forty-five miles from Panderma, a port on the Sea of Marmora, 100 miles from Constantinople, with which city there is a regular service of steamboats.

The principal deposits, as far as yet known, exist near the Tschatalja mountain, in longitude 28° 2' east, and latitude 40° north. It is mined by means of both shafts and tunnels. The boraciferous stratum varies in depth, the nodules or borate being disseminated through the gypsum and other earthy impurities with which it is associated, and from which it has to be selected and picked. The material is hauled to Panderma in "arabas," or native ox carts, or else packed on the back of camels. It tests from 40 to 44 per cent. of boric acid. The present annual yield is from 8,000 to 9,000 tons.

There are other minerals existing in different parts of the globe that contain boracic acid, but either the quantity, the quality, or other difficulties exist that prevent their being dealt with commercially. They are interesting mineralogically.

The manufacture of borax, as far as the English are concerned, divides itself into two classes—the manufacture of borax from boracic acid and that from sesquiborate of lime and double borate of lime and soda.

The mere refining or recrystallizing of crude borax requires no skill at all. The manufacture of borax from boracic acid imported from Italy involves several processes. The sulphates of ammonia and magnesia have first to be washed out of the crystallized acid, and this is effected by reason of their superior solubility. The boracic acid is then boiled in large iron pans, with the requisite amount of carbonate of soda, the impurities allowed to subside, and the clear liquor run to large iron vats to crystallize. This first borax is not pure enough for commerce, and requires a second crystallization.

The impure borax liquors are boiled down, and upon reaching a strength of 60° Twad., or 1,300 specific gravity, are allowed to recrystallize and throw down a further crop of borax. Before the mixture reaches a temperature of 30° Fahr. it is drawn off into other vats to allow the sulphate of soda to crystallize out, and, finally, the liquor is raised to the boiling point, and concentrated, in order to get rid of the common salt.

Borax manufactured from boracic acid is liable to be tinged with various colors, such as black, green or yellow, on account of impurities contained in the acid or the soda ash, and are due to the presence of sulphides or oxides of iron. In order to overcome this difficulty the borax is bleached when in a state of solution.

The manufacture of borax from boracite, colmanite, or ulexite presents a new feature that does not appear in the manufacture from boracic acid, and that is, that when any of these minerals are reduced to a state of the finest powder, and boiled with carbonate of soda, what is known as borate of soda, as well as biborate of soda, is formed.

The biborate of soda or borax crystallizes out in the ordinary way, but the borate of soda remains as a thick sirupy liquor, which has to be decomposed either with carbonic acid, boracic acid, or bicarbonate of soda. If this is not done, loss is apt to occur, and the full strength of the mineral is not obtained.

With such abundant and redundant supplies of borate of lime throughout the world, it becomes a question of transporting the boracic acid it contains in as concentrated a form as possible, especially in those regions where the quality is but poor, and, therefore, many plans have been devised. One of the simplest is what is known as the sulphurous acid process, and this is to be preferred to others on account of the small quantity of sulphur required to extract the boracic acid.

The process consists in burning sulphur, and injecting the sulphurous vapors into the decomposing vessel, where the borate of lime is kept in a state of agitation and suspension in water.

Only one ton of sulphur is required to produce five tons of acid, and the saving effected in cost of transportation, where it takes two or even three tons of borate of lime to produce a ton of boracic acid, requires no recommendation.

The price or value of borax has probably interfered to a great extent with its more general use. The fluctuations can be better described by a diagram on the wall, and shows the value in London and New York for the last twenty years.

In 1872, owing to a combination, the price was forced up to over £100 a ton, since which time, owing to the American and Asia Minor supply becoming developed, the price has declined, increased and declined again. And at the present time the curious circumstance exists that the price of borax in America is higher than it is in England. America, of all places in the world! The way it came about was this. Prior to 1883 Italian boracic acid was admitted into the United States duty free; so some of the borax manufacturers applied to Congress to put on a duty, as it was ruining the borax industry. This Congress obligingly consented to do, and put on a duty of 4 cents a pound. There has been a duty on borax of foreign manufacture all along; but American borax, shipped from San Francisco to New York, via Panama or round the Horn, is admitted duty free. Even if American borax is shipped from San Francisco to Liverpool, it can be reshipped to America and admitted duty free. Still the price of borax in the United States went down until, in 1885, it was sold at £21 per ton in San Francisco. It then occurred to the borax producers to combine and put up prices, which in 1887 they did, limiting the production to the requirements of the United States, and selling to actual consumers in a few other countries. The price was put up to the full extent of the tariff on borate of lime and boracic acid. And so the consumers of borax in the United States, where there is probably more borax than any other section of the globe, have to pay more for it. You will notice that twenty-eight industries, owing to the action of the protection policy of the United States, thus suffer to benefit one.

But in order to maintain that price the Americans are restricted to the consumption in their own country, for fear of their borax being bought at the current price in England, and shipped across to New York to compete with the higher prices there.

Various estimates have been made of the consumption of borax throughout the world, and one of the methods of ascertaining this is by referring to the productions of different countries and converting the different materials into their equivalent of borax. We thus find the production to be as follows:

	Tons.
Asia Minor	8,000
Thibet	2,000
Italy	3,000
United States	6,000
Chili and Bolivia	3,000
Total	22,000

As the American and Asia Minor supply has been developed within the last 20 years, it will be seen that the uses of borax, to the extent of 14,000 tons per annum, have increased during that period, or nearly 300 per cent., and it may be taken for certain that its uses will still further extend.

In the discussion which followed Mr. Arthur Robottom said he was neither a chemist nor a geologist, but he had traveled much in search of borax, feeling sure that its general use would be a great value to the world. He was the first to bring it from California, and having a large stock of course he tried how he could dispose of it, and to what uses it could be put. He, therefore, induced the butcher in the village where he resided to let him have some cowhides, which he treated with borax. He then had them tanned and sent the leather to Northampton, where it was pronounced to be as fine as any in the world; in fact one man was so pleased with it that he had kept a specimen in his window ever since. When he first went to America borax was little known there except to druggists, but he spoke about it, and got its uses noticed in the papers. Rambling in the Death Valley he saw a dead horse lying on the ground, and pulling out some of the hair and finding it perfectly firm he cut a piece of flesh with his knife and found it perfectly sweet, although, as he ascertained afterward, the carcass had been lying there a long time. He got this noticed in the California papers, from which it was copied into others, and that was the beginning of the use of borax as a preserving agent in America, a use which had now become so general. Near the Death Valley there was a deposit of crude borax, which he discovered about a foot under the blue mud. When this was removed the borax was accessible; and when the sulphate of soda was dissolved out, it was tolerably pure. He sent a cargo of it home round Cape Horn, and felt very proud when it arrived. It was a very toilsome journey to get there, for there was no railway then; and he had 212 miles to walk, through a very difficult country; but he felt amply repaid, when he found the borax, knowing it would have the effect of bringing the price down, and putting it within the reach of all.

With regard to its effects on the human system, he believed Sir Henry Thompson had spoken of it as deleterious, but he took it constantly, and was never out of health, and he had cured many sore throats with it, for he always kept a supply of it about him. Sir Joseph Lister was the first to use it as an antiseptic in medicine, and if people could only be taught to use it in their socks it would be an immense boon to soldiers, policemen, postmen and others who had a great deal of walking to do. The great difficulty was to get shopkeepers to sell it, but he did his best to make its virtues known. He had been in communication with hundreds of chemists on the subject, and he always endeavored to find out what their customers said of it. The antiquity of tincal as an import from Thibet was considerable. He had reason to believe that it was brought by caravan from beyond Shata to China, and hence by way of Babylon and Palmyra to the Mediterranean ports before the Christian era. In 1707 the price of tincal in London was £9 5s. a cwt., or £185 a ton; and in July, 1756, from a price current, he found it was £14 a cwt., or £280 a ton. Of course at such a price it could not be used for washing. The great thing to be desired was that it should be low in price, so that washerwomen might use it instead of soda; they would not get sore arms, and if they had such it would cure them.

ON THE MAGNETIZATION OF METALS.

By THOMAS T. P. BRUCE WARREN.

IT is well known that if a bar of iron or steel be magnetized, there is a linear increase in the magnetic "line of direction," but I am not aware of any previously published experimental data showing whether the increment is cubical, or whether the extension in length, or "line of direction," is accompanied with a diminution in the other linear directions of the mass. My experiments, which have been frequently repeated, show that there must be a diminution in the transverse section of a rod, for the same rod, when magnetized, occupies the same bulk as before being magnetized; in fact, there seems to be a slight diminution. I hope to deal more fully with this portion of the subject in a future communication.

I cannot find that any experiments have been made showing the effects of *cubical* compression. If, for instance, a bar of iron or steel be rigidly prevented from altering its dimensions, would it be possible for the same to acquire a high degree of magnetization relatively, when under no restraint? The solution of this problem might throw much light on the behavior of the dipping needle when traversing a country where magnetic rocks are supposed to exist.

Bearing upon this, we must not omit to take into account the screening effect due to the magnetic permeability of the various geological deposits overlying a stratum of high magnetic susceptibility.

An arrangement which I designed some time ago, and which I termed a "torpedo finder," is based upon these facts. The position of a submerged torpedo, anchor, or any piece of iron may be indicated by means of the magnet, but, unfortunately, the low permeability of water involves the lowering of the magnet to within a short depth of the plane containing the submerged mass.

An electromagnet, or solenoid, may be made magnetically stronger than an ordinary magnet. The electromagnet is lowered to within a few feet of the bottom, the depth of which has been previously ascertained by careful sounding. The electromagnet is excited by a primary or secondary battery. By means of a delicate dynamometer, the strain due to the electromagnet and its leading wires is noted, the battery power is increased, when any increased pull will indicate the existence of some disturbing cause in the neighborhood; by keeping the magnet clear of the bottom and gently steering, we avoid uncertainty in the dynamometer indication, as is experienced in dragging over a rough or uneven bottom.—*Chem. News.*

THE TELEPHONE AS AN OPTICAL CURRENT MEASURER.

By MAX WIEN.

THE author arranges his "optical telephone" as follows: A thin corrugated German silver membrane, such as is used for aneroid barometers, is provided at the middle of that side which is toward the electro-magnet with a piece of soft iron and on the other side with a pin. The latter presses against a piece of very fine watch spring steel, one end of which is fixed, while the other carries a very light mirror. A telescope is used to throw the image of an illuminated slit on the mirror.

If a constant current is allowed to pass through the apparatus, the membrane changes its position of equilibrium; the beam of light is displaced, and remains so as long as the current does not alter. This displacement is proportional to the current intensity, and can

* For illustrations of Borax Lake, California, and works, see SCIENTIFIC AMERICAN SUPPLEMENT, No. 733. For illustration of Chilean deposits, see SUPPLEMENT, No. 561. For early history of the California deposits, see SUPPLEMENT, No. 572.

be experimentally regulated. Since the telescope allows 100 divisions of the scale by tenths to be observed, and one division may be made to correspond to about 5×10^{-8} amperes, a conclusion as to the sensitiveness attainable can be arrived at.

Although the "optical telephone" is thus highly suited for constant currents, it is still better adapted for those which alternate. If a simple sine current passes through the apparatus, the membrane vibrates and with it the mirror. Instead of an ordinary displacement a band of light is then produced, the breadth of which is a measure of the amplitude of the sine current.

It is, however, necessary that the natural tones of the membrane and the spring and the number of alternations of the sine current should be in correspondence with one another. This may be easily effected so far as the membrane and the spring are concerned, and also for the current, if the latter is derived from an induction coil, the contact breaker spring of which is brought to the right tone.

By comparing the results with those given by a dynamometer, the proportionality between the displacement and amplitude of the current was experimentally established. The author shows how with his apparatus he has measured self-induction and fluid resistance with alternating currents. Finally, he gives a table showing the conductivity of dilute sulphuric acid of specific gravities between 1·200 and 1·250. The maximum value $691{\cdot}9\times.10^{-3}$ is reached at a temperature of 17·3° C. at a specific gravity of 1·224.—*Wied. Ann.*

THE NEW ENGLAND PORTELECTRIC COMPANY'S SYSTEM OF TRANSPORTATION.

SINCE the close of the exhibition of the model of the portelectric in the "Old South Church," Boston, over a year ago, persistent and unremitting efforts have been made to determine all the conditions necessary for the construction of a commercial line for practical business purposes. Much delay has been caused in the progress of the work by the severe and uncalled for test to which the invention was put by the contracted course which the company was compelled to adopt, and which gave little opportunity for straight runs, so essential to the development of high speed.

The present experimental track is situated at Dorchester, Mass., and the tests have been carried on under the supervision of Mr. J. T. Williams, the inventor of the system, assisted by Prof. A. E. Dolbear, the electrician of the company. In a report recently made by Franklin L. Pope, we gather some interesting details as to the methods employed and the possibilities of the system.

The experimental plant at Dorchester comprises an endless track, Figs. 1 and 2, elevated upon a wooden trestle a few feet above the ground, 2,794 feet in circuit, consisting of one tangent of 492 feet and another of 430 feet long, united at their ends by two curves, one of which is 1,092 feet long and 282·5 feet radius and the other 780 feet long and 234·4 feet radius. The track in the first tangent of 588 feet is level, while in other portions of the circuit are grades rising to a maximum of 4½ per cent., or 237 feet per mile.

The track consists of an upper and a lower rail, formed of bar steel ¾ inch by ¼ inch, fastened by countersunk screws to stringers. The upper stringer is of wood, 2 inches square, and the lower also of wood, 2 inches broad by 4 inches deep. The upper rail is supported and braced at intervals of about 3 feet.

The carrier, Fig. 3, is a hollow cylindrical projectile of wrought iron, with ogival ends, the cylindrical portion being 8 feet long and 10 inches in diameter, the length 12 feet over all, and the weight approximately 500 pounds. It has capacity to contain, say, 10,000 letters, weighing, perhaps, 175 pounds. It is provided with two flanged wheels above, and two underneath all of which, being fitted with ball bearings, revolve with very slight friction.

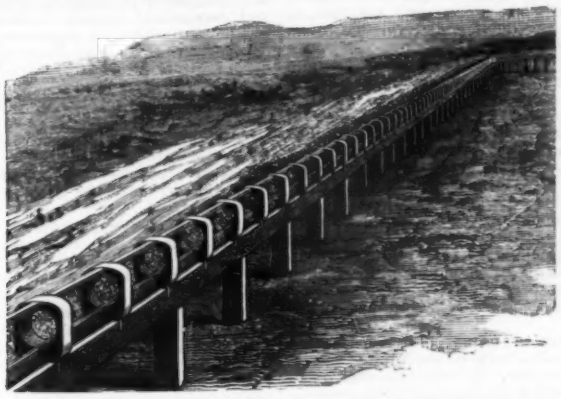


FIG. 1.—PORTELECTRIC TRACK AT DORCHESTER, MASS.

The propelling power is derived from a series of hollow helices of insulated copper wire, each of which encircles the track and carrier. These are fixed along the permanent way at intervals measuring 6 feet from center to center. Each helix is composed of 630 turns of No. 14 copper wire, in five layers, weighing about 20 pounds, and having a resistance of about 5 ohms. A contact wheel, mounted upon the carrier, and running in contact with the upper track rail (which is divided into sections, and utilized as an electric conductor), connects the several helices in succession with the source of electricity as the carrier moves forward upon the track.

The electric current is supplied by a dynamo having a maximum capacity of about 8,000 watts, or a little over ten horse power, driven by a steam engine rated at ten horse power.

Experiments were first made to determine the maximum speed of carrier which could be obtained from the appliances in use at the time of inspection. This was found to be 2,784 feet in 56·5 seconds, or 49·3 feet per second, equal to 33·5 miles per hour.

The consumption of electric current, or rate of electric work while the carrier was in motion, was between nine and ten electric horse power. The maximum tractive effort with a current of ten amperes was found to be 80 pounds. The electrical force producing this magnetic attraction was 6,300 ampere turns.

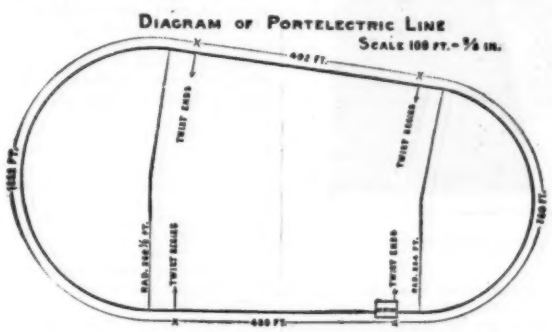


FIG. 2.—DIAGRAM OF EXPERIMENTAL PORTELECTRIC LINE.

The rate of acceleration was found to be as high as 4·5 feet per second. The force of traction required to produce this acceleration, with the carrier of 500 pounds weight, is about 70 pounds.

A tractive effort of 70 pounds, exerted upon the carrier moving at the rate of 50 feet per second, requires the expenditure of 6·3 horse power, or 4,712 watts. As the average electrical energy supplied appeared to represent something like 8,000 watts, the efficiency of the helices and carrier, considered as an electric motor, may be estimated at about 60 per cent., which figure agrees very well with other determinations of solenoid magnets.

There are eight hundred and eighty helices, and seventeen thousand six hundred pounds of insulated wire per mile in the helices, in addition to that in the main conductors.

As each coil is ordinarily in circuit for only a fraction of a second at a time, it is evident that a volume of current per unit of sectional area may be used with impunity in this case which would be wholly inadmissible under ordinary conditions.

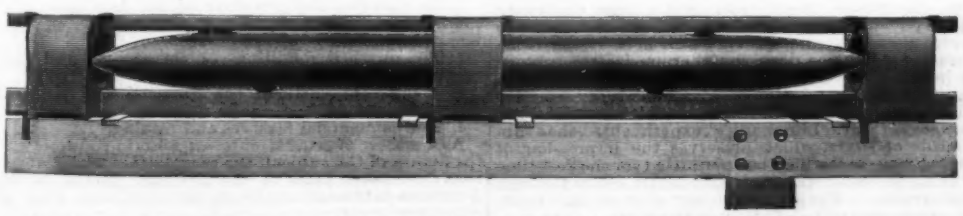


FIG. 3.—CARRIER OF THE PORTELECTRIC SYSTEM.

The provision for power required to propel the carrier at the assumed rate of 150 miles per hour may be taken at fifteen hundred volts and seven amperes per forty miles of single track, or about 0·33 horse power of *generating capacity* per mile. This may be estimated, including steam plant and buildings, at $125 per horse power, or say $45 per mile.

The actual cost of the electric power required to propel the carrier at this rate may fairly be taken at five cents per horse power hour, including cost of attendance at stations. The mere cost of *power* for propelling a carrier from Boston to New York would, therefore, not exceed seventy-five cents per trip.

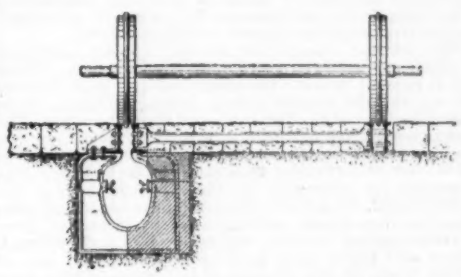
Excessive estimates of the cost of a double track line, making liberal allowances in all directions, do not exceed $35,000 per mile, or about $7,000,000 for a line between Boston and New York.—*Elec. Engineer.*

THE ELECTRIC TRAMWAY AT BUDAPEST.*

By F. UPPENBORN.

THE use of overhead conductors for tramway purposes introduces in many plants almost insuperable difficulties. In many large towns especially it will not be possible to obtain the permission for this kind of working, and the choice will therefore mostly have to be made between accumulators and underground conductors. Traction by means of accumulators has many points preferable over the other arrangement. Independence of a central station, which was formerly considered as a chief consideration, has gradually lost its importance in the course of successful endeavors to raise the safety of central station working on the one hand and the security of the connection of the electric car to the central station on the other. The most important advantage arises from the fact that accumulator cars can at once use the existing tramway lines. Against this advantage there are, however, many considerable disadvantages, among which we may point merely to a striking one—namely, the absence of an accumulator thoroughly suitable for tramway purposes and tested by lengthy work. This reason was at the time of choice of the system for the electric tramway at Budapest even more preponderating than it is at present, when we are, at any rate, in possession of satisfactory accumulators for stationary purposes. The decision was therefore made for underground conductors.

The electric tramway as it has been carried out and is already working in three streets of Budapest is a slotted conduit system, and in exterior appearance hardly differs at all from ordinary tramways. As shown in the cut, the rails, corresponding in some degree to the rails of the Haarmann system, are separated by a gap of 33 mm. (1·3 in.) One rail of the track is screwed by means of wrought iron angular fish plates on 18 cm. (7·1 in.) wide cast iron frames corresponding to the profile of the conduit running beneath this rail, and designed to receive the conductors. The conduit has an oval, egg-shaped profile, 28 cm. (11 in.) wide and 33 cm. (13 in.) high; at its upper side it has a 33 mm. (1·3 in.) wide gap corresponding to that of the rail, so that, as in other conduit systems, the slot in the rail leaves the conduit open at the top along its whole length. The iron frames, on which the double rail is screwed, occur at intervals of 1·2 m. (4 ft.) Besides supporting and fastening the rail they serve also as skeleton to the conduit, and, further, they carry the insulators supporting the electric conductors. The conduit, the whole of which runs at a constant depth of 57 cm. (22·44 in.) beneath the upper border of the pavement and rail, is built in concrete between the iron frames, the frames being used as guides. The rails have the requisite strength to bear with safety any street loads occurring between the two supporting frames. The lateral pressure of the pavement, tending to straighten the gaps between the two single rails, is sufficiently provided for by the angular fish plates.



SECTION OF BUDAPEST ELECTRIC TRAMWAY.

The second rail of the track has only a subordinate importance, as no conduit extends beneath it. It can be, therefore, carried out on any system, such as the Phœnix rail, as Vignoles rail without furrow, eventually even as a simple flat rail. In Budapest, for this second rail, the double tram rail of Haarmann has been used. Its two single rails are held together by bolts, and the two double rails of the line are connected together at intervals by track rods, as shown.

In the inner flanges of the iron frames, box-shaped insulators are inserted, carrying the electric conductors inside the conduit. The conductors consist of angular iron bars, which have, at a sufficient conductivity, the requisite strength to resist the wearing away caused by the friction of sliding contacts. The two conductors, one of which serves as lead and the other as return, lie perfectly protected beneath the rails, so that from without they can be neither seen nor touched. The conductors are situated so high above the bottom of the conduit that the surface water collecting in the conduit can flow away beneath the conductors without coming into contact with them. Shaft drains, to admit the surface water, are arranged at intervals close to the conduit. The water, after being separated from any possible slime, flows out of these

* Translated from *Elektrotechnische Zeitschrift.—Electrical Engineer.*

shafts into street drain. The bottom of the tramway conduit being only 70 cm. beneath the upper surface of the pavement, an injury to town drains and conduits is entirely excluded. On the other hand, a considerable advantage could be obtained over the ordinary tramway by employing a flat rail, as in this case, for each track there would be only a single furrow on the street surface

The electric car differs from the common horse tramcars only by the absence of the shafts, etc., instead of which it has at each of the two front sides a buffer that serves at need to couple several cars to a train.

Beneath the car, between the two axles, is placed the electromotor. The revolutions of its armature are transmitted by means of a chain gearing to one axle of the car, which thus becomes the driving axle. The field magnets are made, as in the older construction of Siemens machines, of flat iron bars, the considerations of a better use of material having been subordinated to the tendency of reducing the weight of the machine as much as possible.

The speed is regulated by four groups of resistances placed beneath the car platform. The switching in and out of these resistances is effected by means of a cylinder shaped switching apparatus, which is situated in a case beneath the driver's seat, and which can be actuated from each end by means of a switch crank there placed. The switch crank allows the switching out and stopping of the motor as well as the reversing of its rotation.

This arrangement provides a very safe management of the car, which is one great advantage of electric over horse and steam traction. In case of danger the driver is enabled, by a simple rotation of the switch crank, to reverse the movement of the motor, and, in connection with the operation of the brake, to bring about an almost instantaneous stoppage of the car. Among other advantages of the electric system may be mentioned the need of a very much smaller depot. In comparison with horse tramcars the electric car is shorter by the length of the team. In the same way an electric car is much smaller than a steam car of equal available seating space.

The current is led to the car motor by means of a sliding contact arm running between the two angle iron conductors and carried forward by the moving car. The working pressure is 300 volts. Several cars can be run contemporaneously on the same track.

At Budapest there are at present in operation three lines with underground current conduction, namely, (1) the Stationsgasse line since the 30th July, 1889; (2) the Podmaniczkygasse line since the 10th of September, 1889; and (3) the great Ringstrasse line since the 6th of March, 1890. Besides these, there are (4) the Friedhof line in course of construction, for which electric propulsion by means of overhead conductors is in view; (5) the Konigsgasse line already conceded; and (6) the Quay line in course of negotiation.

The central station for furnishing the necessary working current is situated at 22 Hartnergasse. There are at present in use four steam boilers, each having 100 sq. m. (120 square yards) heating surface, three steam engines, each of 100 h.p., and three dynamos. The steam boilers are of tubular type, the steam engines are horizontal compound condensing engines, each of which drives a dynamo by means of rope gearing. The dynamos are connected to the collecting bars of the switchboard, from which the current is separately conveyed to the single railway lines by means of iron-sheathed patent lead-covered cables laid underground. There are three such feed conductor pairs, one of which leads to the crossing of the Podmaniczkygasse with the Ringstrasse, another to the crossing of the Stationsgasse with the Ringstrasse, and the third to the Ringstrasse corner of the Dohanygasse. The feed conductors terminate in junction boxes placed at the three points mentioned, from which, by means of short conductors, the different rail lines are separately supplied with current.

For sheltering and supervision of cars there are erected service stations at the end points of the two radial lines. The car sheds are provided with two turnstiles, connected by rails with the Podmaniczkygasse line. The car shed is also in connection by means of the turntable with a repairing shed for four cars, which contains the necessary machine tools for smaller repairs. These machines are operated by an electromotor fed from the tramway mains.

The rolling stock includes at present 50 electric cars and eight spare cars. The working speed has been fixed by the city authorities as follows: The maximum speed is 15 kilometers (9·32 miles) per hour. In the outer Podmaniczkygasse it may be raised up to 18 kilometers (11·18 miles). On the other hand, in some of the narrower streets where there is much traffic, the speed is to be lowered to 10 kilometers (6·21 miles), and at crossings of main intercourse streets to 6 kilometers (6·73 miles).

In consequence of this greater working speed against that of horse tramways, the utilization of the rolling stock is also very favorable. Each car performs, at 16 hours' day service, 120 to 130, and even up to 150 car kilometers (respectively, 75 to 81, up to 93 car miles). In a technical respect, also, the Budapest railway has proved a perfect success. All arrangements, and particularly the neat underground arrangements, have proved excellent, and the Budapest railway may thus become a precedent for many other electric tramway plants in towns having much traffic.

The results of the working brought together in the following table are considered as exceedingly satisfactory:

TOTAL TRAFFIC RETURNS FOR ALL THREE LINES SINCE THE OPENING TO THE END OF DECEMBER, 1890.

Lines in Service.	Stationsgasse. Opening of Service, July 30, 1889.	Podmaniczky-gasse. Opening of Service, Sept. 10, 1889.	Ringstrasse. Opening of Service, March 6, 1890.	Totals.
Trips	114,838	91,051	110,156	316,045
Car kilometers	367,581	318,678	202,428	888,687
Passengers carried	1,694,290	914,491	2,325,370	4,934,030
Passengers per car kilometer	5·85	3·87	8·23	5·54

EDMUND BECQUEREL.

IT would be impossible to retrace the so well employed existence of Alexander Edmund Becquerel, or to make a summary of his long and illustrious career, without going back to his eminent father, Antony Cesar Becquerel, who may be considered as the founder of a scientific dynasty, since, among our most distinguished physicists, we still enumerate Mr. Henry Becquerel, the son of him whom death has recently taken away from his labors.

Physics has the Becquerels, as the natural sciences have the Jussieus and the Milne-Edwards—splendid examples of heredity in these privileged families, in which the qualities of intelligence are verified from father to son by the love of work and truth.

Edmund Becquerel, who was born at Paris on the 24th of March, 1820, was the second son of Antony Cesar Becquerel, the immortal creator of electrochemistry, who, after leaving the Polytechnic School, in 1808, and after having as an officer of government engineers passed through the Spanish war and the French campaign of 1814, was elected member of the Academy of Sciences on the 20th of April, 1829. Edmund Becquerel, in his early childhood, received a most careful scientific education. He was admitted to the Normal School in 1837, and to the Polytechnic School in 1838. In the same year the young and studious pupil became assistant in the course on applied physics, of which he who was both his father and his master was professor at the Paris Museum of Natural History.

It will suffice to enumerate the successive titles that Becquerel obtained in order to give an idea of his assiduity and his perseverance. In 1840 he was made doctor of sciences, and was soon conducting the course of physics, as an assistant, at the Faculty of Paris (1844). In 1850 he obtained, in a competition, the chair of physics and meteorology at the Agronomic Institute of Versailles. After the suppression of this establishment, in 1852, he was appointed on the 30th of December of the same year professor of applied physics at the Conservatory of Arts and Trades. On the 18th of

EDMUND BECQUEREL.

May, 1863, he was elected a member of the Academy of Sciences in the section of physics. Since 1838, the indefatigable worker had been continuously publishing numerous memoirs in the *Comptes Rendus* of the Academy of Sciences, the Annals of Chemistry and Physics, the *Bibliotheque Universelle*, of Geneva, the Annals of the Agronomic Institute, the Annals of the Museum, and the Annals of the Conservatory of Arts and Trades.

These memoirs, very elaborate and often of a capital importance, relate to electricity, magnetism, optics and meteorology.

Among Edmund Becquerel's researches upon electricity must be cited in the foremost rank those that he made upon the laws of the electro-chemical decomposition of bodies, upon the disengagement of heat as a consequence of the passage of electricity in circuits, upon the disengagement of electricity through mechanical, physical, and chemical actions, and upon the properties of electrified bodies.

Between 1849 and 1855, our learned physicist made a particular study of the action of magnetism upon all kinds of bodies. He showed the action of the surrounding media in order to explain the diamagnetism of solids, liquids and gases. He discovered that oxygen was magnetic, and, with respect to other gases, was as iron is to the other metals. The observation of this fact, which is of great interest, led him to demonstrate the intervention of the atmosphere in terrestrial magnetism.

Becquerel's optical researches concerned the constitution of the solar spectrum and the chemical action of light. The able experimenter found that certain rays act only after a beginning of impression under other rays. He studied the development of the electricity due to chemical action, and was led to construct the electro-chemical actinometer, which acts in the same manner for light as does the thermo-electric battery for heat.

In 1848 Becquerel discovered a chemically sensitive substance of which much has been said in recent times *apropos* of Mr. Lippmann's experiments—the subchloride of silver, which preserves the impression of colored rays, and which has permitted for the first time of fixing the solar spectrum with all its colors through photography. The images slowly alter in the light, but are preserved indefinitely in the dark.

In several memoirs Becquerel studies the luminous effects that result from the influence of light upon bodies, and in virtue of which such bodies have the property of becoming sources of light. His labors upon phosphorescent substances will remain among the most remarkable of our time. One of the most accurate of observers, our learned physicist constructed the phosphoroscope, which permits of measuring the duration of phosphorescence. This instrument has permitted of dealing in optics with questions analogous to those that in heat regulate cooling and the quantities of heat emitted or absorbed by substances. The spectral study of the light emitted by phosphorescence has led to a new spectral analysis, giving the most unexpected and important results without destroying the substances submitted to experiment.

In addition to the scientific memoirs of which we here enumerate only the most important, Becquerel wrote numerous works. We shall especially mention the one that he published under the title of "Light, its Causes and Effects" (2 vols., 8vo), and those that he elaborated conjointly with his father: "Treatise on Terrestrial Physics and Meteorology" (1 vol., 1847), "Treatise on Electricity and Magnetism" (2 vols., 1855, 1856), "Epitome of the History of Electricity and Magnetism" (1 vol., 1858).

A very methodical professor, Edmund Becquerel rendered the most important services to the science of teaching. His courses at the Museum of Natural History and at the Conservatory of Arts and Trades contributed to the instruction of several generations of workers. A painstaking operator and a very precise lecturer, he was enabled to hold the attention of his audience and captivate it by the brilliancy of his experiments. As a man, Becquerel showed uncommon courtesy and affability to everybody. He had to the highest degree a respect for truth and family worship.

In the train of so laborious a career, and of a life of work so brilliant by the importance of his researches and discoveries, Becquerel was appointed in succession a member of the Institute, a professor at the Conservatory of Arts and Trades, a member of the Central Society of Agriculture of France, honorary president of the Society of Encouragement, a member of the Royal Academy of London, and commander of the Legion of Honor. He certainly well merited all these honors, but he was enabled to conquer through his elevated character and the exaltedness of his sentiments what is worth still more than rewards, and that is the esteem and affection of his contemporaries. On the day of his obsequies, sincere tears were seen to moisten the eyes of the members of his family and of his friends.—*La Nature.*

AN ENLARGED WATERWAY BETWEEN THE GREAT LAKES AND THE ATLANTIC SEABOARD.*

By E. L. CORTHELL, Member Western Society of Engineers.

THE object of the paper is to state and discuss the question of the practicability of making an enlarged waterway from the Northwest to the Atlantic seaboard and Europe. An enlarged waterway having reference to the great lakes is one adapted adequately to the largest freight carriers of the lakes. The capacity of these freight carriers is assumed to be not less than 3,000 tons of cargo, and whose displacement weight shall not be, when laden, less than 5,000 net tons with a draught of 20 ft. All canals and channels, and projects for the same, that are evidently not equal to these requirements are immediately eliminated from the discussion.

The history of railroads, barge canals, and ship canals, and of unrestricted waterways, teaches that none but channels of the largest dimensions can compete with the economy, speed, and other numerous advantages of rail transportation, particularly in the United States and Canada.

For nearly thirty years, almost from the inception of the development of the West, efforts have been continually made by commercial men to bring the project of an enlarged waterway to a realization, but thus far without success.

As long ago as 1865 an able advocate of this waterway enlargement asked the question, in a public document, "Why should the lake cities with their wealth and resources not import for themselves and transact their own business? The ocean is the prerogative of no State of the Union, and the West will seek the channel which conducts its commerce with the least cost and delay."

If there was force in this remark in 1865, there certainly is a greater force at the present time. If there had been one country only between Chicago and the seaboard along the natural lines of the waterway leading from the great lakes, there would have been built, no doubt, years ago adequate channels following the course of the St. Lawrence River.

Between Chicago, Milwaukee, Duluth, and other ports of the more western lakes and Liverpool there are over 4,000 miles of water navigation, 71 of which only are restricted by obstacles in the channels. Therefore the object of this paper is to ascertain if these natural obstacles can be removed, and whether steamships on the great lakes may not be able to ply between these ports and the ports of the Old World.

The scope of a paper discussing subjects of this importance and extent is a broad one. The entire situation must be canvassed and other than engineering features must be brought into the discussion. We are led at once into an important commercial investigation. The important relations which the railroad system of the country bears to this question must be carefully considered. The subject is therefore discussed on the following lines:

1. Its historical features showing the development of commerce and the increase in capacity of the channel ways demanded by this commerce.
2. The physical conditions of the present and proposed routes.
3. A brief statement of the financial and political questions involved.
4. The commercial features and results.

As a matter of general interest and introductory of the details of the subject, the recent geological changes that have taken place in the drainage of the North American continent are briefly sketched, and there is

* Abstract of a paper read before the Canadian Society of Civil Engineers, Feb. 12, 1891, by Mr. Corthell, also a member of that society.

also given an historical sketch as well as an engineering statement of the combined waterway and sewage channel now being constructed by the city of Chicago between Lake Michigan and the Illinois River. The effect of this channel (depleting the lake of quite a large volume of water) upon the levels of the lakes is discussed as being a question of some international importance. The result of the discussion is that we can dismiss any fears that now exist in regard to the deleterious effects of this channel way upon the harbors and the connecting waterways of the lakes.

The vast water spaces of the great lakes, their length, breadth, and depth, are briefly described and the main facts stated.

The historical features of the various canals and channels now existing are stated.

ST. MARY'S FALLS CANAL BETWEEN LAKES SUPERIOR AND HURON.

This canal was opened in 1855, with two locks 220 ft. long and 70 ft. wide, 12 ft. deep. These dimensions have been increased from time to time. The lock now being built by the U. S. government is 800 ft. long, 100 ft. wide, with 21 ft. of water on the miter sills, and at a cost of nearly $5,000,000.

ST. CLAIR RIVER IMPROVEMENTS.

The St. Clair River improvements between Lake Huron and Lake St. Clair show also an increasing depth and width of channel. This work has also been done by the U. S. government. In 1866 it was made 13 ft. deep, 300 ft. wide and protected by timber dikes. The project under way contemplates a depth of 20 ft. The Lime Kiln Crossing at the mouth of the Detroit River has much the same history as to its increased size. The depth has been increased from 9½ ft. in 1858 to 20 ft. in 1890.

WELLAND CANAL.

A brief history of the Welland Canal is given. The first project was that of 1824 for building a canal and railroad combined, the work having been begun at that time with wooden locks 110 ft. long, 22 ft. wide, and 8 ft. deep. Water was let into the canal in 1829 and two vessels went through in that year. The dimensions of this canal have never kept pace with the size of vessels navigating the lakes. The present locks are 270 ft. long, 46 ft. wide, with 14 ft. depth of water. Up to the present time or to 1889 there has been expended on this work according to official reports, $23,787,950.30.

TRENT RIVER NAVIGATION.

The Trent River navigation, which is brought into the paper for the reason that it is navigated, though by an inferior class of navigation, consists of a series of canals with intermediate stretches of rivers and lakes with a depth of 5 ft. or 6 ft. It extends from Trenton, at the mouth of the Trent River, on Lake Ontario, to Lake Huron. The entire length of the route is 201 miles. Its total lockage 1,044 ft. It is at once apparent that it would be impracticable to improve this circuitous route over an undulating country so as to make of it a ship canal of adequate dimensions.

THE ST. LAWRENCE RIVER IMPROVEMENTS.

One of the most important improvements in the line of what is certain to become an enlarged waterway between the lakes and the seaboard is the deepening of the shallow reaches of the St. Lawrence River between Lake Ontario and its mouth. From Montreal to the sea, a depth of 27 ft. to 30 ft., and of sufficient width, has been obtained by dredging through the shallows which here and there interrupted the greater depths of the river. But the most serious obstacles in the St. Lawrence are above Montreal, where frequently the river flows over a rocky bed in the shape of rapids. These rapids have been flanked by canals. They are the Beauharnois, Cornwall, Farran's Point, Rapide Plat, and Galop. Their combined length is 43¼ miles. The original depths designed by these canals when they were inaugurated in 1841 was 9 ft., but this depth has never been maintained, on account of the fluctuations in the river. At times it falls to 6 ft. 7 in. In 1871 on account of the increasing size of vessels, barges, and boats, it was decided by the government to make a navigable depth of 12 ft. through all the canals and the river shallows, and soon after that a 14 ft. depth was decided upon.

Work since that time has been carried on with this object in view, the standard dimensions of the locks being, length 270 ft., width 45 ft., and a clear depth of 14 ft. on the miter sills. This work has not been, as yet, completed, but, for the purposes of this paper, the work is assumed to be entirely performed. It may be stated in round numbers that the entire amount expended on the St. Lawrence system, from Lake Erie to Montreal, is about 41¼ million dollars and that to finish the work now in hand it will cost about 12¾ millions more, or say $54,000,000 in all. This does not include the construction of a canal at the St. Mary's Falls between Superior and Huron and some other necessary improvements. It may therefore be stated that in obtaining, between Lake Superior and Montreal, a full depth of 14 ft., it will have cost, all told, about $60,000,000.

ERIE AND OSWEGO CANALS.

Between Buffalo and Oswego and the Hudson River at Albany there exists one of the most important means of transportation, so far as the past history of transportation in this country is concerned. This is the Erie and Oswego canals. On the Erie Canal there are 71 locks, 7 ft. deep, 110 ft. long, 18 ft. wide, with a total lockage of 657 ft. The Oswego Canal is 38 miles in length and has 18 locks. The entire expenditure on these canals up to 1886 had been $133,000,000, expended by the State of New York.

LAKE CHAMPLAIN AND HUDSON RIVER.

Another route which has been of service as a barge canal extends from the St. Lawrence River, 46 miles below Montreal, up the Richelieu River to Lake Champlain and thence up Lake Champlain and from this lake to the Hudson River. Eighty-one miles of this canal is in Canada. The total distance is 265 miles, 7 miles of which is by the Erie Canal. The canal is generally of very moderate proportions, being about 36 ft. wide at the bottom, with 7 ft. of water on the sills.

RAILROADS.

One of the most important factors in transportation during the last half century has been the railroad. This method has become so nearly perfect and the cost of transportation by it so greatly reduced that it is able not only to compete successfully with barge canals, but in many cases with transportation on large rivers. In various parts of the United States the successful competition of the railroad with the canals has led to the abandonment of the latter, and where the canal does exist it is generally maintained by taxing the public at large for its expenses. No one wishes to depreciate the immense value which this former means of transportation has been to the country, but we are compelled to state that a better method has come to supersede it, and that the only possible means of competing with this better method is to make one better still.

An idea of the immense business performed by the railroads and of their extraordinary growth will appear from the following facts:

In the year 1840 there were in the country tributary to the great lakes only 89 miles of railroad. In 1850, 1,276 miles; in 1860, 10,238; in 1880, 37,456; in 1889, 63,688, and in that year these railroads moved over 208,000,000 tons of freight. These railroads are in the United States. There are over 8,000 miles more in Canada. The railroads with their advanced methods and improved facilities for transportation have built up great centers of population and trade, which lie directly along what may be made a continuous and adequate waterway to the seaboard.

The immense railroad business transacted at Chicago, one of the ports on the great lakes, will be seen from the following:

Length of main lines of railroad terminating at this city is.....	54,411 miles.
The number of freight cars received and forwarded in 1889	4,248,769
The number of tons of freight received and forwarded.....	43,013,444

HARBORS.

In reference to the harbors of the lakes, the United States government has expended large sums of money in deepening, improving and protecting them, and has begun a system of improvements of equal capacity to the channels between the lakes. Its present policy is to improve these harbors to a depth of 20 ft. The average depth at present in the harbors of the larger ports is 16 ft.

The most important historical feature of the subject is the growth of commerce on the lakes.

1st. In respect to the size of vessels.

2d. The tonnage carried.

In 1859, 36 of the largest lake propellers averaged about 700 tons register, ranging from 583 tons to 981, with a maximum draught, when fully laden, of 11½ ft. The history of the increase in size of vessels is a most interesting one, but the limits of the paper do not permit of this history being traced. But it may be stated in 1890 the business fleet of the lakes consisted of 2,055 vessels, aggregating 826,360 net register tons, the total value being $58,125,500; 232 of these vessels are steamers of over 1,000 tons register, 110 of them are over 1,500 tons, and many of them are from 1,600 to over 2,100 tons, and with a carrying capacity of from 3,000 to 3,700 cargo tons. The draught of these vessels is limited by the depths of the channels and harbors, but many of them could safely and profitably load to 19 or 20 ft. The recent growth of lake commerce is extraordinary, and it is difficult to predict the amount of tonnage upon the lakes and the size of the vessels before the end of the present decade. In 1886 the total valuation of the vessels was about $30,500,000. In 1890, as has been stated, over $58,000,000, and the number of steamers in the same time of over 1,500 net register tons has increased from 21 to 110.

At the St. Mary's Falls Canal, where careful records are kept by the government officials, the increase of commerce is clearly noted. In 1870 the entire amount passing through this canal was 690,826 register tons. In 1880, 1,734,800. In 1883, 2,042,359. In 1887, 4,897,598. In 1890, 8,454,435, and the actual weight of cargo carried in that year was 9,041,213 net tons. The value of the tonnage has increased from about $29,000,000 in 1881 to over $102,000,000 in 1890. The amount of commerce on the great lakes will very favorably compare with the foreign and coastwise commerce of the United States. The tonnage through the St. Mary's Falls Canal is greater than that through the Suez Canal.

While the lake business has thus rapidly increased, the waterways east of Lake Erie have hardly maintained their former traffic. This is true of the Erie Canal, the Welland Canal and the St. Lawrence River canals. No doubt the principal reason for this decline, as it really is, in the business of these artificial waterways is their inadequacy for the business that would otherwise come to them. For instance the Welland Canal has 14 ft. depth of water. According to the United States Bureau of Navigation, report 1889, there were 330 United States vessels in the great lakes above Niagara Falls which drew too much water, when laden, to go through this canal. Eighty-six of these were sailing vessels and 244 steam vessels, with a total tonnage of 444,192, about one-half of the entire lake tonnage. Of those that passed through this canal in the year 1889 most were United States vessels, and they were obliged to reduce their cargoes in order to pass through, from a total tonnage 71,502 to 63,283 tons.

Improved methods of transportation by rail, increase in the size of lake vessels and their cargoes and, principally, the rapid growth of steam transportation on the lakes and rival competition between various lines of lake vessels and the railroads, have compelled continual reductions in the cost of transportation. The records of the business through the St. Mary's Falls Canal show that the cost per ton per mile of carrying freight an average distance of about 800 miles in 1887 was 2·3 mills, and in 1889, 1·5 mills. Careful calculations made by Mr. Charles H Keep, Secretary of the Lake Carriers' Association, given in a paper addressed to the United States Congress, Dec. 5, 1890, show that the value of all the cargoes carried on the lakes the last season was over $305,000,000, the average distance of carriage being 566 miles, or a total of about 15½ billion ton miles. If this had been carried at railroad rates the cost to the public would have been over $143,000,000, but by the prevailing lake rates the cost was only about $23,000,000, so that water transportation on the lakes in one year saved to the public nearly $120,000,000. Much of the heavy freight has been carried for considerably less than 1¼ mills per ton mile. Anthracite coal is carried from Buffalo to Duluth, a distance of 1,000 miles, for 30 cents per ton, or ⅓ mill per ton mile. The lake rates from Chicago to Buffalo on wheat have been reduced from 11 cents per bushel in 1861 to 2¼ cents in 1890. The large steamers with barges in tow can transport grain at 2 cents between Chicago and Buffalo, with a profit.

The increase in population of the lake cities indicates the great increase there must necessarily be in the business of the lakes and also of the railroads tributary to them. The city of Buffalo has increased from about 42,000 in 1850 to 155,000 in 1890. Cleveland, Ohio, from 17,000 in 1860 to 262,000 in 1890. Chicago from 30,000 in 1850 to about 1,100,000 in 1890.

The preceding commercial statements covering nearly three pages of the proof of the detailed paper are so important that the abridgment of them seriously detracts from their effect. They have been compiled from a large amount of detailed information placed in the author's hands through the kindness of the officials of the United States and Canadian governments and by officers of transportation lines and secretaries of boards of trade of the lake cities. The one subject of the growth of the commerce of the great lakes, with the accompanying reduction in freight rates and a description of the methods of transportation, both by water and rail, would of itself form a most interesting and important paper.

With these facts before us it is necessary to take up the physical conditions now existing of the various present and projected routes to the seaboard and ascertain if it is practicable to develop within a reasonable cost such a commercial route as the commerce of the great lakes requires.

St. Mary's Falls Canal with its lock, now being built by the United States government, is the only artificial work on the great lakes that is fully equal to the requirements of commerce. The lock now being built by the Canadian government is to be limited to 18 ft., which the author does not consider as sufficient to meet the increasing size of vessels.

OTTAWA SHIP CANAL BETWEEN GEORGIAN BAY AND MONTREAL.

In reference to projected routes, the first in order is that of the Ottawa Ship Canal between Georgian Bay and Montreal, which has been under discussion by the Canadian government since 1858, when the well known civil engineer, Mr. Walter Shanly, made an examination and report. Two years afterward a second report on this project was made by Mr. T. C. Clarke, civil engineer. Mr. Shanly's project contemplated locks 250 ft. long, 50 ft. wide and 10 ft. deep. His estimate for the entire work was $24,000,000, the total length being 430 miles and a total lockage of 698 ft. Mr. Clarke's estimate for a 12 ft. depth on the miter sills, with locks 250 ft. long, 45 ft. wide, was $12,057,680. Mr. Shanly estimated that the difference between a 10 ft. and a 12 ft. canal would not be less than $5,000,000, so that on the same basis of depth his canal in cost compares with that of Mr. Clarke's as $29,000,000 to $12,000,000. However, the projects were on an entirely different basis, Mr. Shanly preferring to cut canals at the sides of rapids, but Mr. Clarke preferring to raise the levels of rivers and avoid the rock cuttings.

On the plan of an enlarged waterway proposed by the author, with locks 600 ft. long, 85 ft. wide, and 20 ft. deep, with a depth of canal prism of 22 ft., and with a width of canal in short sections of 150 ft., and in long sections of 200 ft., and with 24 ft. depth in the river and in slack water reaches, the cost would be about $83,000,000.

A ship railway has been proposed on this route. In the opinion of the author the course of the river is too tortuous and the cost of removing natural obstructions too great to give this alternative project serious consideration.

GEORGIAN BAY AND TORONTO SHIP CANAL, OR ITS ALTERNATIVE, THE HURON-ONTARIO SHIP RAILWAY.

Next in order is the Georgian Bay and Toronto Ship Canal, or its alternative, the Huron-Ontario Ship Railway, between the same points.

In 1846 a ship canal project was brought forward by Mr. Kivas Tully, civil engineer, of Toronto. In 1851 and 1855 further examinations were made under the auspices of the Board of Trade of Toronto, and at a convention of delegates from Western cities the route was favorably considered. Col. R. B. Mason, of Chicago, was employed as consulting engineer. He made an examination of the route in 1855. The estimate for the canal was $22,170,150. Its length was 100 miles, with 50 locks, with 12 ft. on the miter sills. Very serious difficulties in the way of excavation were found at the summit level, where there was for ten miles continuous cutting with an average depth of 90 ft. and a maximum depth of nearly 200 ft. A company was incorporated for carrying out the project in 1865. Its charter was amended under the name of the Huron and Ontario Ship Canal Company. The project, however, was never brought to the point of actual work.

In 1881 Mr. James B. Eads, at that time engaged on the project of a ship railway across the American isthmus, was requested by several Toronto gentlemen to give an opinion as to the feasibility of building a ship railway between Georgian Bay and Lake Ontario. His opinion, given after a careful study of the subject, was that it was not only practicable, but that the route furnished one of the most favorable locations for such construction. The length of the ship railway route is 66 miles. Mr. Eads' plan was to build three railway tracks of standard gauge, the rails 110 lb. per lineal yard, and the capacity of the railway was for vessels of 2,000 tons displacement weight and 14 ft. draught. The estimated cost was $12,000,000. The author was at that time associated with Mr. Eads and familiar with the plans and estimates. In order to present the subject now in connection with other projects for an enlarged waterway, he considered it of sufficient importance to re-examine the subject and to have a personal examination made of the country by one of his associates, Mr. A. F. Robinson, member of the Western Society of Engineers. The plans and estimates have been reformed on the basis of a ship railway of larger capacity than that contemplated by Mr. Eads, that is, for vessels for a displacement weight of 5,000 tons with a draught of 20 ft., the railway to be capable of transporting during the navigation season 8,000,000 tons of

traffic. The summit to be surmounted is 670 ft. above the mean level of Lake Ontario. The maximum gradient is 33 ft. per mile, though over the larger part of the route the grades will run 11 ft. to 14 ft. per mile. The cost of the railway fully equipped for the kind and amount of traffic contemplated is $15,459,318.09. In the opinion of the author this route and this method of transportation is far superior both in its first cost and in the cost of transportation to the Ottawa Ship Canal, previously described. The differences and the advantages and disadvantages in comparing the two routes are given at some length in the paper submitted to the Canadian Society.

WELLAND CANAL.

To increase the capacity of the Welland Canal to meet the requirements of the proposed enlarged waterway and enlarge and deepen the present locks and the prism of the canal would cost about $25,000,000.

NIAGARA FALLS SHIP CANAL.

It has been proposed by the United States government to build a ship canal at Niagara Falls on the United States side of the river. In 1867, by authority of Congress, an examination was made for this canal, contemplating a depth of 14 ft., with locks 275 ft. × 46 ft. Six routes were examined. In 1888 funds were appropriated by Congress for a second examination for a canal with a capacity of 20 ft. The data from the previous surveys were used in making the plans. The dimensions were to be, locks 400 ft. long, 80 ft. wide, with a depth of 21 ft. The canal was 25 miles in length, with 18 locks, at an estimated cost of $23,617,000. A revision of this estimate on the basis of larger locks and a larger canal prism (the project contemplating only 100 ft. width) and an increase in the price of rock excavation, which the author considers advisable, makes the total cost about $35,000,000.

NIAGARA FALLS SHIP RAILWAY.

As an alternative to the ship canal, estimates have been made for a ship railway on another route, the length of which is 18½ miles. This would require a maximum grade of 50 ft. 4¾ miles in length. On the same basis as the plans of the Huron-Ontario Ship Railway and of the same capacity and for the same annual amount of traffic the cost is $10,731,613.71, with a full equipment.

MICHIGAN PENINSULA SHIP CANAL AND SHIP RAILWAY.

It has been proposed to build a ship canal of the standard dimensions above given across the Michigan Peninsula from Benton Harbor, on Lake Michigan, to near Munroe, near Lake Erie, a distance of about 160 miles. It would require 65 locks and the crossing of 19 railroads. The estimate is $138,405,432. A ship railway across the peninsula on a somewhat different location will cost about $39,000,000. The height to be surmounted is 475 ft.

Still another route might be considered both for a ship railway and a ship canal, and that is by way of Grand River at Grand Haven, on Lake Michigan, through, or near, the city of Grand Rapids, Michigan, to the head waters of the drainage of the Saginaw Bay in Lake Huron. The author has not the data for a careful estimate, but is informed that a depth of 18 ft. or 20 ft. can be dredged eastward from Grand Haven and westward from Saginaw Bay, leaving an intermediate stretch of about 80 miles where a ship canal or ship railway could be built. The location and direction of this route is such that it would take commerce almost in a direct line from Chicago to Georgian Bay and thence by the Huron-Ontario Ship Railway into Lake Ontario. No estimate has been made of the cost either of a ship canal or ship railway by this route.

LAKE CHAMPLAIN ROUTE BY WAY OF THE CAUGHNAWAGA RIVER.

The Lake Champlain route from the St. Lawrence River to the Hudson River has been considered. The estimates made at various times by different engineers, both Canadian and United States, for a 12 ft. navigation averages about $20,000,000 from the St. Lawrence River to Albany. To build this waterway on the plan of the proposed enlarged waterway with locks of standard dimensions, and to deepen the Hudson River from Albany to Hudson City and Lake Champlain, as well over long, shallow reaches where there is now sufficient depth of water for 12 ft., but not for 20 ft., would cost not far from $50,000,000. For the waterway desired, this project is not considered practicable.

ERIE CANAL AND OSWEGO CANAL ENLARGEMENTS.

To enlarge the Erie Canal, and in this case enlargement means an ample enlargement of the canal prism for a long distance, that is between Buffalo and Albany, the cost would probably exceed $250,000,000, and were it ever completed there would still be nothing but a continuous canal where the speed of the vessels would be restricted. The same objections exist in regard to the Oswego Canal enlargement. There has been suggested a ship railway instead of either of the canals. The author considers this impracticable, not only on account of its great cost, but on account also of the natural and artificial obstacles that at points would prevent its construction. The Mohawk Valley is now entirely occupied by two railroads (six main tracks), the Erie Canal, the Mohawk River, at times a turbulent stream, overflowing its banks, and an almost continuous line of cities and towns. These natural and artificial conditions are hemmed in on either side by steep and rugged bluffs of hard rock.

ST. LAWRENCE RIVER ENLARGEMENTS.

The St. Lawrence River enlargements require careful consideration, for the reason that they form the most available natural route for an enlarged waterway, either to receive the traffic over the Huron-Ontario Ship Railway, or the ship canals, or the ship railways at Niagara Falls and across the Michigan Peninsula. The Canadian government has furnished the author, by the hands of the chief engineer of canals and from the department of public works, much valuable information. The estimate is based on these data and from the plan of the enlarged waterway and the standard dimensions used in other estimates in this paper. The total cost of giving the full depth everywhere from Lake Ontario to Montreal, assuming that the present canals have been deepened to 14 ft., is $27,000,000.

COMPARISON OF COMMERCIAL CONDITIONS.

A statement of the commercial conditions of the proposed routes is necessary in order to make a comparison between them. These conditions have an important bearing on the general question of location and advantages, and are therefore stated in full in the body of the paper. The "sailing distances" are steamer distances, and are compiled from many records, a selection being made from the most reliable. The time per hour forming a basis for the total time on each route is open to amendment, being in some respects a matter of opinion, but formed from much study of the subject and from definite records of speed under practical and similar conditions.

The cost of transit is made up from the actual average cost on lines now operated on railroads, lake, and ocean and barge and ship canals. As to the speed, time and cost on a ship railway, while there is no actual transportation of this kind in existence, yet the results of ten years of careful study of the subject on the two principal ship railway projects of the world—the Tehuantepec and Chignecto—are used in this statement. Though made from different conditions and by persons working independently, the results closely agree and may be considered the consensus of the best thought on the subject. The figures, however, await the actual test of practice soon to be applied at the Chignecto Isthmus.

TABLE OF SAILING DISTANCES.

	Statute miles.
New York to Liverpool	3,440
Boston to Liverpool	3,211
Baltimore to Liverpool	3,891
Montreal to Liverpool	3,225

The all rail distance from Chicago to New York is 913 miles via Pennsylvania Railroad, 949 miles via Nickel Plate and West Shore. Chicago to Montreal via Grand Trunk Railway, 837 miles.

SAILING DISTANCES BY VARIOUS ROUTES.

	Miles.
1. Huron-Ontario Ship Railway	1,001·00
2. Ottawa Navigation	978·76
3. Lakes, Welland Canal & St. Lawrence River	1,263·00
4. Mich. Pen. Ship Ry. & Welland Canal	842·25
5. Mich. Pen. Ship Ry. & Niagara Ship Ry	841·00
6. Mich. Pen. Ship Ry. & Niagara Falls Ship Canal	841·00

RATE OF SPEED (STEAMERS).

Rate of speed on the ocean and lakes, 1 miles per hour.

Rate of speed of ship railways and rivers, 10 miles per hour.

Rate from Montreal to Quebec, 10 miles per hour.

Rate on the canals, 7 miles per hour.

Rate on Welland and Niagara Falls canals, 4 miles per hour.

Lockage and ship railway lifts and deflection tables, 30 minutes each.

RECAPITULATION—CHICAGO TO MONTREAL.

	Hours.
1. Via Lakes, Huron-Ontario Ship Ry. and St. Lawrence River	93·14
2. Via Ottawa Navigation	106·17
3. Via Lakes, Welland Canal and St. Lawrence River	126·58
4. Mich. Pen. Ship Ry., Lakes, Welland and Niagara Falls Canal, etc.	107·04
5. Mich. Ship Ry., Lakes & Niagara Falls Ship Ry	90·67
6. Mich. Ship Ry., Lakes, Niagara Falls Ship Canal, etc.	98·39

It is necessary to give the following notes for the purpose of ascertaining the correct basis of the cost per ton per mile. On this basis the tables which follow have been prepared.

ACTUAL RAIL RATES.

From many details furnished in the paper a rate of one-half cent per ton per mile is assumed as the railroad rate over all lines. The rates over the different portions of the water route with the connecting ship railways made to cover cost of operation and 6 per cent. interest on the cost, are as follows:

TABLE OF COST PER TON MILE.

	Mills per ton mile.
Rate over Huron-Ontario Ship Ry	3 1/10
" " Niagara Falls Ship Ry.	7
" on lakes	1 1/2
" " ocean	1/2
" " Mich. Pen. Ship Ry.	3 1/2
" over Mich. Pen. Ship Canal	8
" " Ottawa route	5
" " St. Lawrence Canals	7
" " Niagara Falls Ship Canal	12·5
" " Welland Canal	10

An important condition of the water route which should not be overlooked is the loss in time during the year on account of ice. After comparing many records showing the time of closing and opening of various routes and harbors, the table prepared by Mr. L. E. Cooley, president Western Society of Engineers, appeared to be the most reliable, and was therefore used in the description. The data appear under the proper head in the following table, which is the most important tabulated statement in the paper, as it contains the result of all of the calculations relating to length, time, cost, and number of days of open navigation on each route.

CHICAGO TO LIVERPOOL.

No.	Description of Routes.	Length miles.	Time in hours.	Cost per ton.	No. days route is open.
1.	Huron-Ontario Ship Ry., Lakes and St. Lawrence River	4,226·00	13·47	$3.48	225
2.	Lakes and Ottawa Navigation	4,203·76	326·50	4.59	205
3.	Lakes, Welland Canal and St. Lawrence River	4 488·00	346·91	3.97	225
4.	Mich. Pen. Ship Ry., Lakes, Welland Canal, etc.	4,067·25	327·37	3.66	229
5.	Mich. Pen. Ship Ry., Lakes, Niag. Falls Ship Ry. & St. Lawrence	4,066·00	311·00	3.53	234
6.	Mich. Pen. Ship Ry., Lakes, Niag. Falls Ship Canal & St. Lawrence	4,066·00	318·72	3.70	229
7.	All rail to Montreal	4,062·00	328 33	6.26	234
8.	All rail to New York	4,353·00	337 33	6.74	365

The route and plan recommended by the author is as follows: Via Straits of Mackinaw (or if found to be practicable and economical, the route should cross the Michigan Peninsula by way of Saginaw Bay, either by ship canal or by ship railway) thence by way of Georgian Bay to Lake Ontario by the Huron-Ontario Ship Railway, the St. Lawrence canals and the river, the United States government to build the ship railway or ship canal, across Lake Michigan; a private company under the auspices of the Canadian government, and by a guarantee of interest by that government, to build and operate the Huron-Ontario Ship Railway; the Canadian government to complete the St. Lawrence improvements to the required dimensions and then to remove all tolls from the canals. The cost of carrying a ton of freight from Chicago to Liverpool by this route as compared with the all rail route via New York will be $3.26 per ton as against $6.74. Thus the saving in one year on the estimated traffic of 8,000,000 tons would be more than the entire estimated cost of preparing the enlarged waterway from the foot of Lake Ontario to the sea.

The competition in English and other importing markets of Europe between the wheat of the Northwest, the Pacific coast, India, Russia and the Argentine is so close that a substantial advantage in cost of transportation like the above to both Canadian and United States cereal producers will at once work a revolution in trade, and lead to an important development of agricultural products and to a material prosperity over 450,000 square miles, comprising the basin of the great lakes. This prosperity will extend to the lands outside and remote from the lakes, but capable of reaching its seaports (as the great cities of the lakes will be) by rail or water routes.

SHIP RAILWAYS.

From a long and careful study, in his professional work, of ship railways, the author has without any hesitation placed them on an equality as transportation methods with the ship canal. In fact, he considers the ship railway in many respects superior:

1st. In that the cost of construction is generally about one-half that of the ship canal to handle the same class of vessels and an equal amount of traffic.

2d. The cost of operation and maintenance is less.

3d. The rate of speed is greater and the detention en route is less on account of the absence of locks.

These features have been discussed so fully in published papers during the last ten years in connection with the Tehuantepec and Chignecto ship railways that it is not considered necessary in this commercial paper to go into the detailed proofs of the statement above given.

The Mexican government, the Dominion government and the United States government have each in turn officially, after long discussions and careful examinations and reports, approved of ship railways, and the leading vessel constructors, owners and navigators in England, at least, are in entire accord with the proposition. As an instance of the readiness of our own ship builders to agree to the proposition of a ship railway, it may be stated that only two or three months ago Mr. W. I. Babcock, manager of the Chicago Ship Building Company, engaged in building large steel vessels at this city, in a written communication stated that he believed it to be entirely feasible to transport vessels of the maximum size built by his company (namely, 400 ft. long, 50 ft. beam and of any depth) over the proposed railway between Georgian Bay and Toronto. As to the reduction in cost of transportation by ship railway, it may be stated that this method is the logical result of the increasing size of railroad equipment, both motive power and freight cars. The former have increased from 30 tons to 100 tons and the latter from 10 ton cars to 30, and the transportation rates have been reduced from 2½ cents to ½ cent per ton mile.

If the immense business between the St. Lawrence and the coast of New Brunswick and New England can save 700 miles by operating a railway 17 miles long across the Chignecto Isthmus, why should it continue to take this long and dangerous voyage around Nova Scotia? If engineering skill can provide lifts and a railway and motive power that can haul vessels weighing 2,000 to 2,500 tons, as already arranged for at Chignecto, who will say that it cannot design, construct and successfully operate a railway that will handle vessels weighing 5,000 tons? Necessity knows no law, and this applies to commerce as well as to other things, and the demands of this commerce and of a great people, seeking the markets of the world by the least expensive route, will be satisfied with nothing less than the most approved and economical methods which it is in the power of man to provide.

The question now arises, How can the desired and best route be provided? Will the mutual interests of two great countries between which the St. Lawrence River is the dividing line, in part, and through one of which, having passed an arbitrary line, it finds its way to the sea, bearing the commerce with it, be willing to unite to construct the ship canals and ship railways necessary to remove the obstructions to navigation? Will the great Northwest, both of the United States and Canada, with its millions of people, its rapidly growing cities, centers already of finance and com-

merce, with the constantly increasing business of the great lakes—a common heritage of both nations and free to both and God-given—will these two nations, with so much in common, permit longer arbitrary national boundary lines to remain a barrier to the commerce of both? Shall cities like Chicago, Milwaukee, Duluth, Buffalo, Cleveland and Toronto be longer compelled to send their exports to Europe and receive their imports by expensive channels, when they can load them for Liverpool or Havre at their own wharves, and receive their imports directly at those wharves from the ports of the Old World?

If the routes recommended by the author from the great lakes to the seaboard are enlarged and made adequate for the character and extent of the commercial business now waiting for them, the ports and cities on the great lakes will then have an advantage which they can obtain in no other way. The St. Lawrence route will give to the agricultural producers and to manufacturers, to importers and merchants, and through them to the entire country tributary to the great lakes a direct advantage. Direct trade with Europe should be the demand of the Northwest and of all the country tributary to the great lakes. There can be easily estimated a direct pecuniary advantage of not less than $200,000,000 per annum.

The proposed route lies partly in one country and partly in another. The important question to consider is, whether artificial boundary lines running athwart a natural waterway shall be permitted longer to restrict our commerce, to hamper and delay it and to divert it into unnatural and artificial channels. As civil engineers we ought to promote in all possible ways the development of this commercial route and lend our good offices to the patriotic efforts made in both countries to improve the commercial conditions of each and of what is really after all a common country.

By BENEZETTE WILLIAMS.

In complying with Mr. Corthell's request that I discuss his paper, "An Enlarged Waterway between the Great Lakes and the Atlantic Seaboard," I wish to disown any intention of entering into the merits of the various routes proposed, from an engineering point of view. This could only be done intelligently after an exhaustive study of the detail surveys and other matters pertaining to such routes, which lack of time and lack of data have not permitted. The most that I can hope to do is to make a few suggestions which readily occur to one not well informed on either the engineering or commercial phases of the question. In all matters involving engineering problems I shall rely upon our author, than in whom none can place reliance more safely.

The paper having been prepared for the Canadian Society of Civil Engineers, the author is doubtless excusable if it should develop in the course of the discussion that he lost himself for a time, and temporarily appeared in the role of a loyal Canadian, upon whom the doctrines of reciprocity have not had their perfect work. With the patriotic influences from this side of the lakes surrounding him to-night, we may reasonably hope to see him recover his equilibrium, and view the great problem which he has so at heart from the standpoint of a statesman who would break down all commercial barriers and consult the interests of all the cities upon the great chain of lakes without reference to the allegiance which they acknowledge.

The selection of the Georgian Bay and Toronto route to Lake Ontario would leave the cities on Lake Erie and the Detroit River dependent on the Welland Canal, with its narrow locks and 14 feet of water, for access to the ocean. Buffalo, Cleveland, Toledo, and Detroit, with an aggregate population of 804,324, with their immense commercial and transportation interests, to say nothing of cities of less importance, cannot be ignored when it comes to settling upon a deep water route to the seaboard.

The sailing distance from Chicago to Montreal via the lakes, Niagara Falls and St. Lawrence River, as given by the author, is 1,263 miles. A ship railway from Georgian Bay to Toronto on Lake Ontario will shorten this distance 262 miles, and reduce the time from 109·74 hours to 93·14 hours, a total reduction in time of 16·60 hours. On the other hand the cost of the Georgian Bay and Ontario Ship Railway is given at $15,459,318.09, while the cost of a ship railway around Niagara Falls is given at $10,731,613 71, a saving of $4,727,704.38 in favor of the Falls route.

The cost of transportation per ton via the Niagara Falls Ship Railway, as nearly as I can make out on the basis given by the author, will be 44 cents more than via the Georgian Bay Ship Railway, making the total cost per ton to Liverpool $3.92 instead of $3.48.

The correctness of this comparison, however, is dependent upon the cost per ton assumed by the author for the various portions of the route.

Without undertaking to enter, in much detail, into the cost of transportation by various means, it would be interesting to hear what the author has to say with reference to a few points which render it difficult for me to accept the basis of cost given by him in its entirety.

He gives a table of rates per ton mile for various parts of the route, and various means of transportation, another one of the total cost per ton, and the time, between Chicago and Liverpool. The time and cost in the latter table, as I understand it, is for craft which will pass through channels having 20 feet minimum depth of water, loaded in Chicago and making the trip to Liverpool without breaking bulk, and with the same crew all the way from Chicago to Liverpool.

This being the case, it is hard to understand why the cost per ton mile should be 1½ mills on the lakes and only ½ mill on the ocean, particularly as the speed given for the lakes and ocean is the same—15 miles per hour.

Also, while assuming the St. Lawrence Ship Canals to be free, in the completed scheme, he takes the rate for passage through them as if they are to pay an interest on their cost in tolls, and inadvertently uses this in determining the total cost of carrying freight to Liverpool. This of course does not affect the comparative cost by the different routes that use the St. Lawrence, but it does those that do not.

In this table of rates there is a rather curious anomaly noticeable in the comparative cost of carrying freight over the same routes by ship railways and by canals.

For instance, the rate over the Michigan Peninsula Ship Railway is 3½ mills, and over the Huron-Ontario Ship Railway 3·4 mills per ton mile; while over the Michigan Peninsula Ship Canal it is 8 mills per ton mile. Over the Niagara Falls Ship Railway it is 7 mills, while over the Niagara Falls Ship Canal it is 12½ mills per ton mile. The length of the former is 18½ miles, while the length of the latter is 25 miles. Taking the length into consideration, the cost of transporting a ton of merchandise from Lake Erie to Lake Huron around the Falls over the two proposed routes would be by ship railway 13 cents and by ship canal 31 cents; a marked difference, which to one unacquainted with the proposed method of operating ship railways seems almost incredible.

The freight rate as given by the author from Chicago to the seaboard over different lines of railroads is 5 mills per ton mile, which when compared with the cost given for transportation by ship canals, shows that transportation over ship canals 20 feet deep costs from 40 to 150 per cent. more than by existing lines of railroads.

I believe it is an established fact that the rate per ton mile on the New York Central and Hudson River Railway, from Buffalo to New York City, is as low as upon any road in the United States. Running almost parallel with this road, throughout the whole distance to the Hudson River, is the New York and Erie Canal, with 656½ feet of lockage, and but 7 feet depth of water. But notwithstanding the inadequacy of the size of this canal, and the very small boats which can navigate it as compared with those adapted to navigate a 20 foot channel—a ratio at least as great as 1 to 10—it carries 5,000,000 tons of freight between Buffalo and New York every year, at a cost not exceeding 3 mills per ton mile.

I know that the answer to this is that the railroads pay an interest on their cost and operating expenses, while canals are generally free. To this we may reply that railroads have been improved and double-tracked, sometimes twice over, and their rolling stock has been improved to that extent that in the State of New York the rate for freight per ton mile has decreased from 2·79 cents in 1855 to ½ cent in 1890.

It should be remembered that railroads have been in the hands of active and agressive men, servants of the great corporations, while the canals have generally been in the hands of State legislators, who have to a large extent been also servants of the same corporations. The difference is immense.

Still another anomaly confronts us in the author's table of rates, in that the cost per ton mile by ordinary rail transportation is 5 mills, while that by the proposed ship railways is 3 4 and 3·5 mills, a difference of 30 per cent. in favor of the ship railway. This would tend to show that railways are operated on a wrong system, and that economy in rail transportation lies in hauling ships instead of cars across the country.

While by the foregoing comparison of rates I am led to believe that Mr. Corthell has unconsciously fallen into an undetected fallacy in the cost of carrying freight by ship railways and ship canals, we will for the present waive this point, and merely correct his table of rates so far as it relates to lake and river carriage.

As before pointed out, there is no reason on a through trip with ships of heavy tonnage, why the rate per ton mile on the lakes should be greater than on the ocean. In the following tables I have taken the lake rate at ½ mill—the same as for the ocean—and the river rate at ¾ mill. Aside from the inconsistency of using a different rate on the lakes from that used on the ocean, actual experience shows that ½ mill per ton mile is sufficient for through traffic.

Freight is being carried between Chicago and Buffalo, including terminal delays, for about ⅜ mill per ton mile. Allowing for the terminal delays, ½ mill is found to be ample for through lake traffic. For rivers I use ¾ mill as being the proper rate, based upon the relative speed given by the author on river and lakes, viz., 10 miles and 15 miles per hour respectively.

I.

CHICAGO TO MONTREAL VIA LAKES AND NIAGARA FALLS SHIP RAILWAY ROUTE—TIME, 109 74 HOURS.

Kind of Navigation.	Distance, Miles.	Rate per ton mile. Mills.	Total Cost.
Lakes	971½	½	$0·486
St. Clair River	41	⅝	0·038
Detroit River	27	¾	0·023
Niagara Falls Ship Railway	18½	7	0·130
St. Lawrence Canals	43½	7	0·305
St. Lawrence River	161½	¾	0·121
Total to Montreal	1263		1·103
Montreal to Liverpool. St. Lawrence River and Ocean	3225	½	1·612
Total Chicago to Liverpool	4488		2·715

II.

CHICAGO TO MONTREAL VIA GEORGIAN BAY AND TORONTO ROUTE—TIME, 93·14 HOURS.

Kind of Navigation.	Distance. Miles.	Rate per ton mile. Mills.	Total Cost.
Lakes	730	½	$0·365
Huron-Ontario Ship Railway	66	3·4	0·225
St. Lawrence Canals	43½	7	0·305
St. Lawrence River	161½	¾	0·121
Total to Montreal	1001		1·016
Montreal to Liverpool. St. Lawrence River and Ocean	3225	½	
Total Chicago to Liverpool	4226		2·628

III.

CHICAGO TO MONTREAL VIA MICHIGAN PENINSULA SHIP RAILWAY AND NIAGARA FALLS ROUTE—TIME, 90·67 HOURS.

Kind of Navigation.	Distance, Miles.	Rate per ton mile. Mills.	Total Cost.
Lakes	459·0	½	$0·230
Michigan Peninsula Ship Railway	158·5	3½	0·555
Niagara Falls Ship Railway	18·5	7	0·130
St. Lawrence Canals	43 3	7	0·305
St. Lawrence River	161·5	¾	0·121
Total to Montreal	841		1·341
Montreal to Liverpool St. Lawrence River and Ocean	3225	½	1·612
Total Chicago to Liverpool	4066		2·953

The tables show the cost of carrying freight per ton from Chicago to Montreal and thence to Liverpool, without breaking bulk, on the revised basis as given above, over three of the routes given by Mr. Corthell, viz.:

1. Via lakes, Niagara Falls ship railway, and St. Lawrence River and canals.
2. Via Lakes Huron, Ontario or Georgian Bay ship railway, St. Lawrence River, and canals.
3. Via Lakes, Mich. Peninsula ship railway, Niagara Falls ship railway, St. Lawrence River, and canals.

The above tables show that, granting all that the author claims as to the efficiency and cheapness of ship railways as freight carriers, the route via the Huron-Ontario ship railway has but nine cents per ton advantage over the lakes and Niagara Falls route, and that the Michigan Peninsula ship railway line is at 24 cents per ton disadvantage compared with the same route.

In view of these facts, and of what seems to me the political and commercial necessity that a deep water route to the seaboard should follow the line of the large commercial cities, and should be such as to serve every one alike; and that by the author's estimates the first cost of the route via Niagara Falls is $4,727,704.38 less than via Georgian Bay and Toronto, it seems that the latter route should be finally eliminated from the problem. The same may be said, still more certainly, of the proposed Michigan Peninsula ship railway or ship canal.

This conclusion is made still more emphatic by the fact that by far the greater tonnage which will be carried on such a route is local and not transatlantic, being traffic between upper and lower lake ports. The few hours difference in time which is shown to exist—viz., 16·6 hours—is insignificant when compared to the great commercial and political advantages in following the chain of lakes and rivers which nature has marked out. In such a case a few hours more or less is immaterial except as it may affect the through cost of transportation. This, as shown by the author, amounts to 44 cents per ton between Chicago and Montreal. But by taking the author's real basis, corrected in its application, as heretofore shown, the difference of cost is but 9 cents per ton A slight increase in the cost of carriage by ship railways will show that the Niagara Falls route is materially cheaper. That such an increase should be made, I believe, will become apparent on further consideration of the problem of moving vessels in the manner proposed.

In the discussion thus far I have assumed that Mr. Corthell's conclusions concerning the feasibility of ship railways are, in the main, correct, and that there are cases where they may become a valuable adjunct to water transportation. But in the course of his arguments to establish their value as the carrier of ship and freight, as compared with canals, there must lurk a subtle fallacy, or else past experience in the operation of railroads and canals is misleading. One of the fallacies which the author falls into may perhaps consist in the assumption that it will take no more time for a ship to be placed on the gridiron, or cradle, adjusted properly and hauled out of the water, ready for movement over the main track, than it takes to pass through a single lock on a properly constructed canal. Another one may be in assuming that the movement over the railway will be more expeditious than through a canal. If, in accordance with the author's assumption, 8,000,000 tons of freight will pass over the route during a season of navigation, there will, in all probability, be days when one vessel an hour and perhaps more would pass over the track. This will necessitate frequent siding, and consequently serious delays because of them, or will render a double railway necessary. With a ship canal of proper width there would be one continuous siding so that meeting vessels can pass freely at any point. Hence, it does not seem probable that the movement of vessels over a ship railway can be made more expeditiously than through a canal. It should be borne in mind that on such a route there will be not only the large ships of 2,000 to 3,000 tons burden, but there will be a multitude of small craft, each of which must be handled separately.

The difficulty, and as seems probable the impossibility, of handling 8,000,000 tons of freight in a heterogeneous lot of craft, such as navigate the lakes, in a season, over one line of road is, I believe, demonstrated by the Sault St. Marie Canal. At this canal upward of 9,000,000 tons was passed last year. The lock for the same is 515 feet long, 80 feet wide, with 17 feet of water on the miter sill. In passing vessels it is usual to let in several at a time, and even then, as I am informed, great delays occur not infrequently, and it is at times taxed to its full capacity. To meet the growing needs of commerce, as shown by the author, a new lock 800 feet long, 100 feet wide and 21 feet of water on the sill is being constructed. From such information as I can get on the subject, one line of ship railway could not possibly have handled the traffic of the Sault St. Marie Canal, presented as it is irregularly and spas-

COMPARISON OF WATER SUPPLY SYSTEMS FROM A FINANCIAL POINT OF VIEW.

THIS was the title of a paper recently read before the American Society of Civil Engineers, New York, by J. Leland Fitzgerald, C.E., in which paper the accompanying table was given.

NAME OF TOWN.	Date of First Construction.	Estimated Population.	Miles of Mains.	Number of Taps.	Total cost divided by 3,650.	Annual operating expenses divided by 365.	Pressure in pounds.	Gallons consumed daily in millions.	Foot pounds in millions.	Foot pounds in millions for each $1 of total cost, divided by 2 10th.	Foot pounds in millions for each $1 of daily expense.	Foot pounds for the sum of the preceding.	Foot pounds in millions for total cost, by expenditure of the basis of 10 lbs. pressure.	Minimum meter rates in cents.	Total Cost for 1,000 gallons in cents.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SYSTEM.—PUMPING TO RESERVOIR.															
Cincinnati, O.	1820	275 000	347	31 128	$2 158	$203	100	32 079	26 026	12.3	35.4	9.1	0.91	9	9.1
Baltimore, Md.	1807	400 000	366	66 088	2 994	203	60	34 000	16 982	5.6	37.8	6.1	0.85	8	9.6
Pittsburgh, Pa.	1826	215 000	175	19 073	1 230	548	70	32 000	17 480	14.1	31.9	9.6	1.40	6	5.9
Brooklyn, N. Y.	1856	770 000	397	103 316	3 603	1 603	40	46 978	15 364	4.3	9.6	2.9	0.72	10½	11.2
Philadelphia, Pa.	1800	1 000 000	876	73 039	5 829	1 624	300	88 880	14 749	8.8	9.7	2.5	1.25	20	19.2
Boston, Mass.	1848	400 000	574.3	34 022	3 575	1 362	60	37 481	11 827	5.0	14.0	1.6	0.48	12½	13.6
St. Louis, Mo.	1830	450 000	315	26 000	4 675	2 200	60	31 500	10 456	9.9	4.3	1.4	0.60		36.0
San Francisco, Cal.	1856	250 000	323	32 938	1 128	294	25	19 113	9 536	9.0	39.4	5.2	2.08	10	3.9
Detroit, Mich.	1854	200 000	252	22 658	1 490	247	60	26 079	7 392	8.0	30.0	4.4	1.10	6⅔	7.8
Cleveland, O.	1872	185 000	148	24 072	829	329	40	22 266	6 336	7.6	19.2	6.6	1.42	4⅔	8.7
Milwaukee, Wis.	1847	80 000	27	3 300	450	248	40	20 000	5 918	12.1	23.8	6.6	2.12		3.9
Allegheny, Pa.	1880	100 000	75	9 500	825	124	100	17 924	6 225	7.5	50.2	6.6	0.68	10½	12.6
Omaha, Neb.	1852	155 000	73.4	8 900	1 302	1 482	40	7 500	5 478	4.0	3.7	1.9	0.47		17.2
Jersey City, N. J.	1830	85 000	30	6 000+	413	84	41	16 500	3 788	9.1	45.1	7.6	1.89		4.4
Richmond, Va.	1844	40 000	137.4	11 001	192	68	60	11 183	3 187	16.6	46.8	12.2	2.03	6	4.0
Harrisburg, Pa.	1857	165 000	18		1 378	163	60	6 400	2 994	2.2	18.3	1.9	0.54		15.0
Louisville, Ky.	1858	40 000	42	4 321	138	120	60	10 307	2 490	18.0	19.1	9.2	1.55		5.9
Portland, Ore.	1852	80 000	161	12 207	550	119	35	5 000	2 476	4.5	20.8	3.6	1.02		7.8
Nashville, Tenn.	1850	160 000	63	7 440	734	584	60	8 323	2 413	3.3	9.5	2.3	1.00	5	6.1
Newark, N. J.	1872	70 000	62	1 128	1 174	92	23	12 642	2 151	1.9	23.3	1.6	0.27	15	29.4
Lowell, Mass.	1892	31 000	28	1 200	103	41	70	4 319	1 867	18.1	45.5	12.9	1.03		8.0
Leavenworth, Kan.	1848	21 000	41	6 000	73	70	125	1 800	1 743	23.8	52.8	16.4	2.34		15.5
Cohoes, N. Y.	1831	25 000	88.5	6 967	200	48	60	3 000	1 684	8.1	22.1	5.9	1.31		28.3
Wheeling, W. Va.	1807	35 000	97.2	13 178	1 714	340	60	4 500	1 651	6.2	34.6	5.3	0.67	6	9.0
Erie, Pa.	1870	120 000	66	2 070		192	30	3 335	1 554	0.9	8.1	0.8	0.20	15	38.9
Providence, R. I.	1878	80 000	69.6	10 000	344	64	50	4 923	1 536	4.4	24.3	3.7	0.74	10	11.0
Toledo, O.	1864	45 000	99	1 700	200	138	30	3 700	1 532	7.3	34.1	4.4	1.35		6.5
Wilmington, Del.	1873	60 000	98	4 800	146	62	60	3 272	1 498	10.2	21.6	7.2	1.10	10	7.2
Grand Rapids, Mich.	1854	32 000	53.6	4 447	537	68	70	2 760	1 494	18.6	22.7	9.0	3.00		2.7
Sacramento, Cal.	1872	40 000	78.5	5 559	266	60	30	6 000	1 453	8.7	9.3	2.4	.34	20	24.0
Lawrence, Mass.	1865	75 000	38	1 000	138	149	50	3 500	1 411	5.2	27.6	3.4	.85		9.7
Hoboken, N. J.	1868	24 000	72	4 400	659	109	25	6 000	1 345	9.0	11.4	1.6	1.34	20	6.7
Oswego, N. Y.	1853	220 000	81	7 800	377	61	70	2 370	1 245	1.9	20.0	2.8	.64		13.8
New Orleans, La.	1873	51 400	12	1 044	118	65	60	2 400	1 225	3.2	41.3	8.1	.45	20	18.2
Lynn, Mass.	1876	35 000	28	1 400	172	65	60	1 700	1 162	9.9	19.6	1.9	1.15		9.1
Little Rock, Ark.	1882	35 000	70	4 000	187	68	60	2 000	1 157	5.7	15 3	6.3	.71		11.7
Council Bluffs, Ia.	1878	45 000	60	4 197	122	36	60	1 691	1 079	2.2	27.6	6.4	.67		12.1
San Antonio, Tex.	1871	65 000	32.5	1 699	483	36	60	1 500	1 058	8.3	29.1	6.7	.24	20	34.4
Fall River, Mass.	1881	35 000	32	5 200	169	32	60	4 000	930	5.6	25.0	5.9	.78	20	10.4
Springfield, O.	1836	32 000	25	1 618	113	41	60	1 750	876	7.7	22.0	3.1	1.68		4.9
Lancaster, Pa.	1875	23 000	49.5	3 100	248	68	60	5 267	901	3.6	15.9	3.5	.98	20	8.2
Sandusky, O.	1872	41 000	52.7	998	192	70	40	2 580	874	4.6	12.2	1.8	1.50	20½	16.0
Manchester, N. H.	1860	55 000	50	5 016	393	49	30	3 047	855	2.3	11.5	1.9	.45		4.6
Camden, N. J.	1868	28 000	54.4	5 495	387	110	30	2 500	833	2.2	5.6	2.5	.53		17.7
Salem, Mass.	1866	36 000	45	3 000	278	22	60	1 250	623	13.2	22.1	2.8	1.50	15	14.3
New Bedford, Mass.	1864	35 000	16	1 300	47	27	80	900	608	2.8	11.7	3.4	.70		15.4
Elizabeth, N. J.	1828	25 000	26.6	3 256	200	69	40	1 767	607	3.6	13.7	1.9	.31		5.3
Lynchburg, Va.	1872	27 500	18.4	1 700	161	41	60	2 256	562	4.8	6.6	1.9	1.13	15	26.2
New Fort, Ky.	1870	22 000	40	9 102	123	41	30	2 441	405	3.6	4.7	3.4	.95		11.7
Poughkeepsie, N. Y.	1855	40 000	32	1 700	151	61	30	1 767	193	16.2	6.0	1.9	1.02½		7.1
Trenton, N. J.	1866	30 000	32	1 150	12	41	35	671	149	2.5	22.30	2.2	0.91	15	8.6
Springfield, Ill.	1872	26 000	11	1 080	42	28	24	780		6.88		4.65	1.01½		7.9
Quincy, Ill.	1856						Average								9.0
Petersburg, Va.															11.77
SYSTEM.—DIRECT PUMPING.															
Chicago, Ill.	1862	775 000	638.2	100 000	$3 132	$2 794	25	91 648	19 017	6.0	6.8	3.3	1.28	8	6.4
Buffalo, N. Y.	1802	250 000	250	29 467	1 238	349	30	38 485	9 863	7.7	27.4	6.0	2.09	3	4.2
Kansas City, Mo.	1873	160 000	85	7 786	1 238	154	90	10 002	7 470	6.0	48.5	6.4	1.60	15	13.9
Minneapolis, Minn.	1867	95 000	112	8 698	391	187	80	10 814	7 181	38.4	40.3	5.4	1.55	10	5.3
Columbus, O.	1870	52 000	70.2	5 207	219	84	70	5 516	3 379	10.3	24.1	8.3	1.18	7	6.9
Savannah, Ga.	1871	45 000	32.6	2 800	93	80	30	5 715	1 423	10.5	12.2	14 9	3.96		2.1
Des Moines, Ia.	1870	60 000	40	2 500	276	100	40	4 000	1 328	17.1	50.4	4.0	0.50		16.5
Evansville, Ind.	1871	25 000	17	1 300	138	60	60	1 500	1 328	4.8	14.4	8.3	1.32		6.2
Schenectady, N. Y.	1874	31 000	28	1 523	41	69	60	2 000	1 058	25.8	11.3	17.0	2.00	8	6.2
Davenport, Ia.	1867	45 000	47	3 000	237	69	40	3 000	996	4.2	11.3	3.2	.53		15.3
Peoria, Ill.	1873	32 500	28	1 911	124	44	40	2 823	934	8.0	6.2	4.6	1.15		5.1
East Saginaw, Mich.	1859	46 000	30	4 728	215	52	60	2 785	800	14.5	53.2	6.3	1.39		6.2
Augusta, Ga.	1869	55 000	37	1 799	270	32	60	1 851	768	2.8	14.7	2.4	8.25	10	2.7
Dayton, O.	1872	33 000	25.8	1 232	118	41	60	1 000	752	6.3	23.8	5.0	.46		17.9
Bay City, Mich.	1877	30 000	19.5	1 477	86	39	90	800	747	13.5	18.2	7.7	.85		6.5
Burlington, Ia.	1863	40 000	28	1 450	55	30	110	2 378	730	13.2	18.7	7.8	.71		9.0
Topeka, Kans.		30 000	30	3 925	218	49	30	1 575	592	2.2	14.4	2.2	.73		10.7
Norfolk, Va.	1874	66 000	37	2 000	124	25	40	1 400	523	4.2	10.6	3.0	.75		10.8
Atlanta, Ga.	1880	35 000	30	1 669	88	22	40	1 250	463	5.4	18.6	4.2	1.05		8.0
Ft. Wayne, Ind.	1873	40 000	28	800	110	68	30	1 500	363	3.8	16.5	3.1	.88		9.0
Terra Haute, Ind.	1866	30 000	28	2 500	151	44	40	725	374	3.4	5.4	2.1	.70	▲ 15	13.0
Covington, Ky.	1876	25 000	54.6	2 892			Average		241	1.6	5.2	1.2	.30		26.7
Taunton, Mass.										8.54	23.21	5.94	1.23▲		9.6
SYSTEM.—GRAVITY.															
New York, N. Y.	1835	1 700 000	620	180 000	$10 970	$1 644	10	110 000	9 130	0.83	5.56	0.79	.79	13½	11.5
Washington, D. C.	1851	160 000	128	22 095	2 338	38	20	26 148	4 340	1.9	114.3	1.83	.91	10	9.1
Troy, N. Y.	1880	60 000	53.2	5 250	322	140	60	8 000	3 964	12.4	24.5	8.6	1.43	15	5.8
Worcester Mass.	1852	79 500	110	8 110	482	259	100	4 000	3 320	6.3	12.8	4.4	.44	15	18 5
Springfield, Mass.	1873	40 000	81.5	4 819	367	68	90	4 000	2 988	6.2	43.3	6.8	.75	10	10.9
Hartford, Conn.	1844	48 000	90	5 836	467	78	60	5 000	2 490	8.1	32.0	4.5	.75	10	10.9
Portland, Me.	1867	34 000	96	6 425	418	40	60	7 200	2 390	6.0	62.2	5.5	.92		9.1
Rochester, N. Y.	1872	130 000	216	17 000	1 063	63	40	7 000	2 324	1.6	28.8	2.1	.82	5	16.0
Oakland, Cal.	1866	65 000	164	7 400	1 430	330	50	4 000	2 246	10.1	7.0	4.6	.32		28.1
Reading, Pa.	1873	60 000	58.9	21 940	320	40	40	2 246	1 341	5.2	4.5	8.6	1.19	10½	9.0
Holyoke, Mass.	1860	31 500	42.4	2 713	132	22	72	2 250	822	8.7	50.9	4.6	1.06	▲ 10	6.8
Elmira, N. Y.	1880	27 000	40	1 540	143	36	44	175	73	6.14	1.6	0.51	.10		7.9
Altoona, Pa.	1871	30 000	35.8	5 272	98	44	60				35.46	4.16	.77		81.1
							Average								17.0

modically. Then it should not be forgotten that if ample facilities were furnished, the tonnage to pass over such a route as that to the seaboard is likely to grow far beyond the limit of 8,000,000 tons per year.

From the various considerations I am forced to the conclusion that it would be useless to start on a ship railway enterprise on any portion of such a route with less than a double track all the way through. This would have the effect of increasing the capital account from the first by almost 100 per cent., certainly by as much as 75 per cent., which alone would increase the rate per ton mile materially, and even then I believe it can be shown that such a railway would have less capacity than a ship canal.

There are still other reasons for thinking that the cost of shipment via ship railways should be greater than given by the author, and that the comparison with canals as shown in his table of rates is at fault.

It has been found that the operating expenses of railroads amount to about 66 per cent. of their total income, that is, two-thirds of the money collected for carrying freight and passengers on railroads goes for operation and one-third to pay interest on invested capital. If it be granted that it will take a relatively smaller proportion of the total earnings to operate a ship railway, it is still probably not out of place to assume that the cost of operation capitalized will, when the traffic is heavy, nearly if not quite equal the first investment. There is, of course, a possibility that there are cases, even when plenty of water is to be had to feed a ship canal, that a ship railway will prove the cheaper, including first cost and cost of operation, and such a case may be the passage from Lake Erie to Lake Ontario around Niagara Falls.

There is another matter of interest suggested by Mr. Corthell's paper, about which I have made some endeavor to obtain information, but without success, and that is, the carrying capacity of ships which can be built, adapted to navigate the lakes, canals 20 feet in depth, and the ocean, plying between Chicago and Liverpool, and other freight ports. Can such vessels be made of sufficiently great capacity to compete on the high-seas with ships engaged exclusively in the ocean carrying trade? To do this it is to be presumed that such ships will have to be of, at least, an equal capacity to those nondescripts known as ocean tramps.

These questions open up a phase of the subject which should have thorough consideration before such an enterprise as that proposed is undertaken, and a depth should be fixed upon, which will place lake ports on a par with those on the seaboard, so far as the handling of freight is concerned, barring their extra distance from foreign ports.

The figures showing the immense and rapid increase of commerce on the lakes, given by Mr. Corthell, are sufficient to convince the most skeptical of the folly of undertaking such an enterprise on any other than the broadest lines. In such an undertaking depth should be sought rather than directness of course, and the ability to touch all important points rather than the mere shortening of time by a few hours. The service to which such a waterway would be put is that of carrying freight, rather than passengers. Do what you will, passenger travel will always follow the line which can be traversed in the shortest time, without regard to cost. What is needed is that channel which will carry the grosser kinds of freight the cheapest without regard to a difference of a day or two in time.

To me it seems clear that we do not need to go beyond the data established by Mr. Corthell, with so much work and painstaking, to establish the route via the lakes, Niagara Falls, and the St. Lawrence River as the proper one for an enlarged waterway to the seaboard. On this route a twenty-foot depth already obtains to the Falls, and a twenty-four foot depth can doubtless be obtained at a cost which will be moderate as compared to its importance. As to whether a ship railway or a ship canal should be built around the Falls is a matter which can only be settled after a careful preparation of plans and estimates, and after the object lesson which is being given at Chignecto shall have been completed and better learned. As to the feasibility and expense of improving the St. Lawrence to a twenty or twenty-five foot depth, let those speak who have more material to work from than I have. This much, however, is clear to me, that if it were necessary to spend from one hundred to two hundred millions of dollars to get a wide channel twenty-five feet in depth from Chicago and Duluth to the seaboard, no better outlay of this amount of money, from a commercial point of view, can be made. If Mr. Corthell's paper is the instigating cause of a movement which ultimately culminates in such a fruition, the whole country will owe him a debt of gratitude which money cannot pay.—*Journal of the Associated Engineering Societies.*

RIVETED JOINTS IN BOILER SHELLS.*

By WILLIAM BARNET LE VAN.

THE high steam pressure which boilers are now carrying renders it desirable that the utmost care should be taken to unite the various plates of which they are composed in such a manner that the joints shall not only possess great strength when constructed, but also that they shall be but little influenced by wear and tear.

A riveted joint is, in a certain sense, an imperfect part of a structure. It cannot be so designed as to be strained uniformly throughout. It has always certain surfaces materially weaker than the rest, at which, consequently, deterioration of material, or fracture, by the action of the load, is liable to occur. These surfaces of weakness are so related that the increase of area of the one involves a diminution of area of the other.

The joint, therefore, which will carry the greatest load before fracture will be that in which the stress reaches the breaking limit for each of those surfaces simultaneously. Since the rivet section can in general be increased only at the expense of the plate section in the strongest joint, the rivet and plate will reach their breaking strain simultaneously under the same load.

It would seem, therefore, that the proper proportions or respective areas of a riveted joint could be determined by the ordinary rules of applied mechanics without the need of experiments. But that this is not so is probably due mainly to a second condition of imperfection in riveted joints. To apply the ordinary rules for the strength of materials to riveted joints, it is necessary that the distribution of the stresses on the respective surfaces should be known.

If those stresses were as uniformly distributed as in an ordinary bar test for tension or shearing, the problem would be simple. But, in fact, the stresses are less uniformly distributed, and the law of their distribution is unknown. Consequently, the average stress on the surface of fracture of a riveted joint, when broken by a load, is less than it would be if the stress were uniformly distributed, and needs to be determined by special experiments. Further, it may be different for different forms of joint. This average stress, always less than the maximum stress which causes fracture, is here termed the apparent breaking stress. Hence, the chief object of experiment on riveted joints is to determine the apparent breaking stresses—

(1) For the different surfaces at which each joint may fracture.

(2) For the different forms of joints.

In certain cases allowances may have to be made for progressive deterioration of a joint, by corrosion or otherwise, which reduces the strength in certain directions more than in others. No experiments showing the amount of deterioration in such cases appear to have been made.

It is well known that the greatest strain upon plates of cylindrical boilers comes upon the horizontal joints, the pressure tending to burst the shell in the radial direction. The pressure of the steam upon the heads and the strain upon the transverse seams or joints is but one-half that tending to rupture the longitudinal joints. Besides this, the heads, in some cases, being dished are additionally strengthened (the extent of the dishing being equal to a radius of the diameter of the boiler shell), and in the case of flue boilers the heads are strengthened by the flues and tee-iron (T) girders on the flat surfaces above the flues connected by rods generally attached to the center shell plate, but better still when stayed from head to head connected by turnbuckles, so it will be seen that the weakest points are the longitudinal seams.

In all boiler joints it is important that the rivet holes in the various plates and braces should coincide perfectly with each other, and that they should be completely filled by the rivets. If they do not all correspond accurately, they should never be forced to do so by the use of a drift pin. Rivets should be placed in those rivet holes which agree properly, and the remainder should then be reamed out until the holes coincide.

The strong competition in boiler making, and the ruling low prices at which work is contracted for to be delivered, have caused great carelessness in this industry. In my experience as a boiler inspector, I have found boilers made by parties who stand high in the trade in which the plates were not punched to properly coincide; so little so, that they formed eccentric openings to receive the rivets, through which a drift pin had been driven to allow the rivet to enter. The use of the drift pin is a relic of barbarism; it not only overstrains the boiler plate, but inclines the hole so that the rivet will not be at right angles to the plate. The strength of such a rivet may be *only twenty per cent.* of that of a driven rivet in properly punched plates. A drift pin should *never* be used. When rivet holes do not coincide they should be reamed until they do, and then rivets of proper size to fill them should be used.

Commercially, boiler plates cannot be drilled or punched with sufficient accuracy to coincide with one another, therefore, all rivet holes should be punched (say) at least one-sixteenth of an inch less in diameter than the rivet's diameter after being driven, and when all the plates are brought well together in place, by temporary bolts, the holes should be reamed to final

* A paper read at a meeting of the Franklin Institute. From the journal of the Institute.

rivet diameter by a *fluted* reamer—not the common half-round reamer in general use in a majority of boiler shops. With rivet holes properly spaced, punched or drilled, and reamed as described above, with the outside and inside of the hole slightly countersunk by a *die*—not cut away—the value of the joint may be safely trusted at sixty-five per cent. of the plate value for single and eighty per cent. for double riveted joints.

The fact that the greatest strength of any structure is only equal to that of its weakest part is equally true of steam boilers.

I will, therefore, give my practice in securing the strongest practical joint. The proper proportion of the seams of boiler shells to obtain the greatest strength is the aim of all engineers.

In the majority of boilers commercially made, the rivet section area exceeds that of the plate section area as much as *forty per cent.* This should not be so.

It is well known that the majority of plates used for boilers is weakened by the amount of material punched out, and that that which is left after punching is very much deteriorated, around the holes, if inferior plates are used, by the strain to which the metal has been subjected, on account of the large clearance allowed by a majority of boiler makers between the diameter of the punch and that of the bolster or die.

The effects of the strains to which plates are subjected, due to the large clearance allowed, as well as from the use of inferior boiler plates, can be seen by examining any ordinary punched plate rivet hole. The material always has a peculiar granular appearance, showing that the fiber has been destroyed; and by taking a piece of boiler plate which has been punched, planing it through the center of the punched holes and rivets, and then polishing the section and applying dilute muriatic acid, the effect of the punch upon the fibers of the iron can distinctly be seen.

In addition to holding boiler plates together, rivets have another function to perform, which is to keep the joints water and steam tight. To do this they must be placed near enough to each other to hold the plates together, thus preventing them from leaking between the rivets. If the rivets do not fill the holes, there is also danger of their leaking around the heads. Now, a badly fitted or crooked rivet, obviously, will not hold the plates together so well as one which is perfectly straight and fits the hole accurately. Any one who has ever observed two plates which have been punched rivet size (by this I mean the size the rivet becomes after being driven, the usual practice being to punch the holes one-sixteenth or 0·0625 of an inch greater in diameter than the diameter of the rivet to be used), and placed together, knows it is impossible to make the holes correspond with any degree of accuracy, and that they must either be strained into position by driving a drift pin into the holes or else reamed out to get the rivet to enter. The manner in which rivets are practically fitted will be seen from the following, Figs. 1 and 2, made from pieces of old boilers, planed through the center line of the rivets.

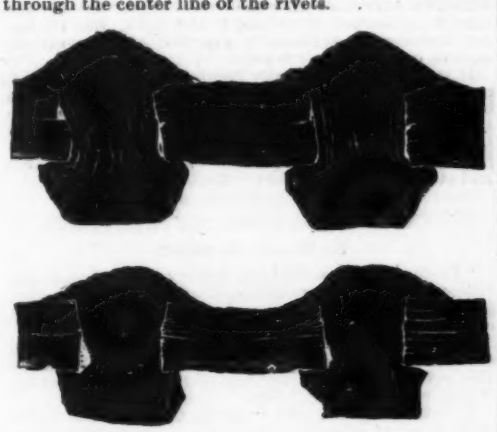


FIG. 1.

From these sections impressions with ordinary printer's ink were transferred to blocks and engraved, therefore they may be relied upon as entirely accurate. They are by no means examples of the worst specimens, as they were selected at random from old boilers. The engraver has endeavored to reproduce the appearance of the fiber of the iron caused by the punch passing through it. It will be seen that the metal for a space of from one to three sixteenths of an inch around

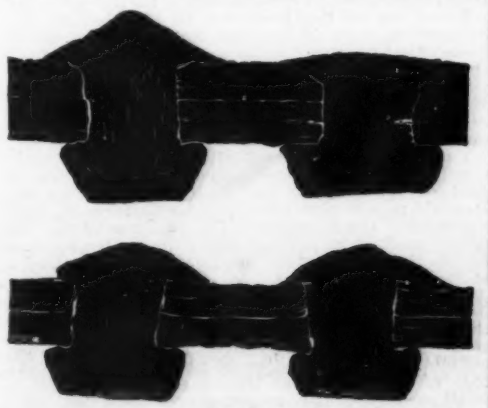


FIG. 2.

the hole has been "fatigued," or strained, so that apparently little of its strength is left Of course, where iron is subjected to so great a strain, besides injuring its fiber, there is danger of cracking it and thus creating a flaw. It will also be seen that the holes do not correspond with each other, and hat, therefore, some of the rivets are crooked and some do not fill the holes.

It will also be seen by Figs. 1 and 2 that the rivets are fitted so badly into the holes that they would evidently resist very little shearing strain, which must be taken by the adjoining rivets. It is true that when plates are held together there will be considerable friction between them, but this friction may not act simultaneously with the resistance to shearing, owing to irregularity of surfaces, so that the force acting upon the boiler plates might be resisted first by the rivets and then by the friction of the plates upon each other. The total strength of the plates is, of course, less, separately, than when taken together. Now, if the holes were fair and the rivets driven into the holes properly, the strain on the seam would be resisted equally by all of the rivets conjointly, instead of by a portion only, and also by the maximum friction of the plates.

To get the best result, I have, in my practice, specified in boiler contracts that all rivet holes shall be punched the size of the rivet to be used, and that when the plates are in their respective positions, held by temporary bolts, the holes shall be reamed one-sixteenth of an inch diameter with a fluted reamer, after which the inside and outside of shell plate shall be countersunk by a steel die (not cut away by a sharp-edged tool).

By the above process the annular ring around the rivet hole, due to detrusion of the punch, is removed, the metal which is left between the holes of the plate is uninjured, and consequently is much stronger than would be the case if the holes had been punched or drilled full rivet size. The countersinking of the rivet holes, as shown in Fig. 3, will be filled up by the rivets

FIG. 3.

and thus add materially to the strength of the latter at their weakest point.

By punching the holes of a smaller diameter than the driven rivet size, and afterward reaming the same in place, the minimum reduction in area of the plate by punching will be attained, and consequently the maximum strength of the complete structure; and as the rivets will be much better fitted, they can be spaced farther apart, thus leaving more metal in the plates, while at the same time the latter will be held together equally well.

With the holes punched small and reamed to full rivet size, they will always conform exactly with each other, even with careless workmanship, so that the danger to which we are always liable with boilers whose rivet holes have been punched or drilled—that of having undue strain fall upon some of the rivets—will be obviated, and at the same time the metal left between the holes will have more strength than when punched or drilled in the usual way; the danger of leakage around the rivets will be obviated to a great extent, and, therefore, they can also be spaced farther apart.

By increasing the diameter of the rivets, their transverse sectional area is increased much more rapidly than the longitudinal section of the holes they must fill, so that giving them sufficient strength does not involve taking away an equal sectional area of the plates.

Besides the weakening of the plate by the strain to which it is subjected by careless punching, there is always a degree of uncertainty about the strength of seams if the plates are punched to full rivet size, which must be a fruitful cause of weakness and consequent disaster. Every engineer, boiler maker, or person who has made even the most casual observation in a boiler shop, knows that as the holes are laid out and punched separately to full rivet size, they never *correspond exactly*, however great the care taken in spacing. Frequently they all come obliquely, and must either be reamed out for a larger rivet, or else the plates are strained by driving in a drift pin to force them in position, in order to bring the holes near enough over each other to allow the rivet to enter. That they do not fill the holes when the plates are in such a position is distinctly shown if a seam be planed through the center line of the rivets, as shown in Figs. 1 and 2.

Now, suppose that some of the holes in the two plates come in relation to each other, as they often do, in the manner represented in Fig. 4. In such an event

FIG. 4.

it will be almost impossible to make the rivets fill the holes unless the latter are reamed out much larger than the size they are punched. If this is done a larger sized rivet must be used, which can be made to fit accurately, but entire dependence must be placed on the faithfulness of the workman employed to do this—a reliance, the uncertainty of which only those who have had experience know, and which, I regret to say, of late years seems to be growing more and more insecure. Now, the fact that workmen *could* do good work if they would, does not lessen the danger from this source. In making boilers with rivet holes punched to full rivet size there is always a risk of bad workmanship, and, what is worse, it is always out of sight and therefore undiscoverable.

With boiler plates carelessly punched to full rivet size there is also danger that some of the rivets will be subjected to an undue strain. If, for example, we have three rivets, as shown in Fig 5, of which only the center holes correspond with each other, and consequently are the only ones which are fitted accurately by a rivet, all the others will fill the holes probably somewhat as in Figs. 1 and 2, or as shown in Fig. 6. Now, if the middle rivet in Fig. 5 should fit accurately, while all the others should fit as shown in Fig. 6 (which probably frequently does occur), then the center rivet must bear all the strain until the others are drawn up to a bearing.

There would, of course, under such circumstances, be very great danger of shearing off the rivet, or of starting a fracture in the sheet, as indicated by the dotted line, *a b*, in Fig. 5. When once started the constant expansion and contraction from the strain in the boiler would, of course, have a tendency to increase it, until there would not be sufficient strength left to resist the steam pressure, and a "mysterious" (?) explosion would result.

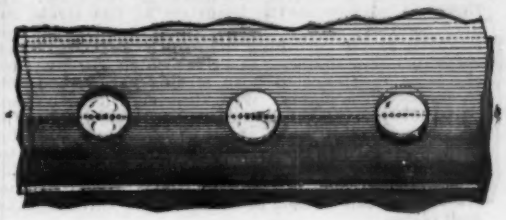


FIG. 5.

Therefore, I claim that just so long as boiler plates are punched or drilled full rivet size there will be difficulty in getting the holes to correspond exactly with each other, and danger from bad workmanship will exist.

This difficulty and danger can be entirely overcome by using the best material and punching the rivet holes one-sixteenth of an inch less than full rivet size, with an excess of plate area over that of the rivet, and when the parts are in place, reaming the rivet holes to full rivet size; those portions of the plate left between the holes will then be from *ten to twenty per cent.* stronger than the commercially made boilers at the present time.

The additional cost of making boiler joints in the manner above described is insignificant as compared with the practice in vogue, and in view of the great advantages gained. To illustrate, the additional cost of an eighty horse power boiler constructed by one of our leading boiler makers, in the manner contended for, was only fifteen dollars.

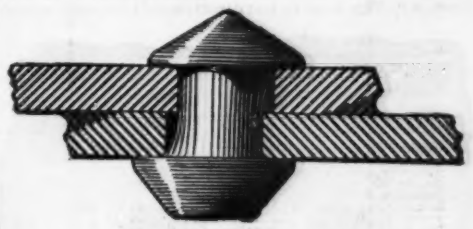


FIG. 6.

When we take into consideration the advantages gained by the buyer in having a better made structure, which will be capable of doing more work by the increased steam pressure at which it will be practicable to run it, the increase in cost will be a good investment.

From the foregoing, it will be seen that a single riveted joint, made as described, will be twenty per cent. stronger than the ordinary riveted plates having the rivet holes punched or drilled full rivet size. As has been shown, this difference in strength is attributable partly to the injury done to the plates by punching and to the presence of the injured parts. When the holes are punched of a smaller diameter than full rivet size, and afterward reamed to the latter dimensions, the reaming removes all the portions injured by the punch. Furthermore, all the rivet holes coincide exactly with each other, and, therefore, the rivets will fit perfectly and will also be less likely to leak. For this reason the rivets can be spaced farther apart, and by increasing their diameter slightly, their sectional area will be sufficiently great to equal that of the plate metal left between the holes, as shown in Fig. 7, composed of three-eighths inch plates.

The objection raised, as before stated, to spacing the rivets, for three-eighths inch plates as shown in Fig. 7,

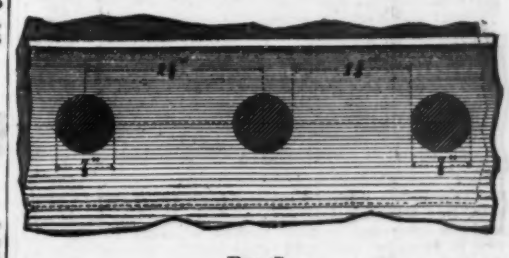


FIG. 7.

is that the seams are liable to leak between the rivet holes. In other words, the plates will not be held together tight enough to prevent the forcing of steam and water between them. The greatest distance that rivets may be spaced apart without incurring danger of leakage between the plates must, however, be determined more by practical than theoretical considerations. What I wish to make clear is that a boiler joint will be stronger if the diameter and distance apart of the rivets are increased in the proper proportion to each other.

There is, however, a limit beyond which the diameter of rivets cannot be increased with advantage, because if we increase their diameters, their sectional area to resist shearing is increased in proportion *to the square of the diameter*, whereas the section of metal in the plate to resist crushing is increased only *as the distance between the holes.*

A given increase to the diameter of the rivets will

therefore increase their sectional area much more than the material of the plates will be cut away by enlarging the rivet holes.

This will be apparent if we compare a rivet one-half inch in diameter with one inch in diameter. The first has a sectional area of 0·1963 square inch, the other 0·7854 square inch, or *four times* that of the first one. Now the area which resists the crushing strain of the rivets is increased only in proportion to their diameters, or *twice* as much for the one as for the other. If, therefore, we increase the diameters of the rivets, we very soon reach a point at which the plate has less strength to resist crushing than the rivet has to resist shearing. The diameter of a rivet which will give just the same resistance to both strains varies with the thickness of the plates. With three-eighths inch thick plates a seven-eighths inch diameter rivet will have a resistance to shearing of about 30,000 pounds, and the three-eighths inch plates in front of it a resistance to crushing also of about 30,000 pounds. A seven-eighths inch diameter rivet is, therefore, the largest sized iron rivet which can be used to advantage in three-eighths inch plates.

If now we were to space such rivets so far apart that the metal left between the rivet holes would equal the area of the rivet in cross section, we would have a strength just equal to that of the rivet; we would have the strongest possible seam or joint that can be made with a single row of rivets.

In plates three-eighths inch thick and seven-eighths inch diameter, rivets of the above value being employed, the distance between the margins of the rivet holes would be one and three-fourths inches, or two and five-eighths inches from center to center of rivet holes. (See Fig. 7.)

I have been explicit on this point, because the distance of the rivets apart has an important bearing where double-riveted joints are used. The advantages of double-riveted joints over single-riveted joints are that the strain is distributed among a greater number of rivets, and therefore the rivets may be smaller, and consequently less material cut out of the cross section of the plates for the rivet holes.

All engineers are aware of the great advantage gained in double-riveted joints by placing the rivet holes in two rows alternately to each other, or in spacing them "zigzag" or "staggered," as shown in Fig. 8, which represents three-eighths inch thick plates, which is the thickness in most general use for steam boiler purposes.

It has been found in practice that for the greatest strength, the distance K between the center of rivet holes, *a e*, Fig. 8, or in the direction of the joint, should

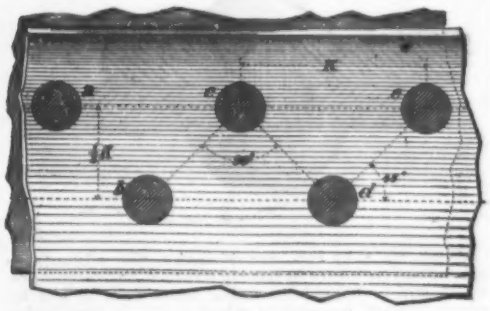


FIG. 8.

be double the distance ½ K between the center lines of rivet holes of the two rows, and the rivets will then form a right angle or 90° with one another. The distance between the rivet holes in the direction of *a c*, or the joint, can be made fifty per cent. greater than between rivet holes in single-riveted joints. The diagonal distance between centers of rivet holes should be made equal to the distance in the direction of the joint in single riveting.

In regard to spacing rivet holes zigzag, as shown in Fig. 9, it will be seen that the rivets in the respective

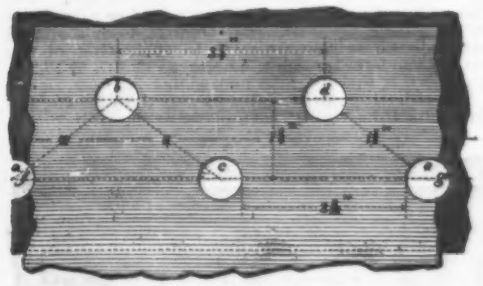


FIG. 9.

rows are much nearer together than those in the same row, but the sectional area plate in the line *a b c d* and *e* is over two square inches, whereas in the line *f g* it is only one and nine-tenths square inches. Therefore, although the rivets on the zigzag line are nearer together than those in the same row, yet the line *a b c d* and *e* presents more material to resist rupture. The strongest joint of this kind will be one in which the material between the rivet holes—say *b d*—in the same line is equal to two of the spaces, *a b* and *b c*, between the rivets in adjoining lines. Or, to express it algebraically, and supposing x to represent the distance between the circumference of the rivet holes, *b* and *d* and m, and n equal to that between *a* and *b*, and *b* and *c*, then we ought to have:

$$x = m\ n$$

In order to make the strongest double-riveted joint of this kind, we must, therefore, first determine upon the greatest distance which is admissible between the rivet holes in order to keep the boiler joint steam and water tight. Assuming this distance to be one and three-eighths inches, as shown in Fig. 9, then the spaces between the rivet holes on the *same line* should be two and three-quarters inches. If the plates are punched less than full rivet size, and when in place reamed to full rivet diameter, the sectional area of the rivets should be equal to that of the plates between the rivet holes. (This is assuming that the tensile strength of plates and rivets are in equal value to each other, or nearly so.) As there are two rivets to resist the strain due to the space between the adjoining rivets, as *b d*, for example, therefore, the sectional area of each rivet should be just half that of the plate section between the rivet holes, *b d*. With a three-eighths inch thick plate this latter area would be one and three-hundredths square inches, the half of which would correspond very nearly with the area of a thirteen-sixteenths inch rivet.

Having the distance between the rivet holes on the same line and the diameter of the rivets, it is, of course, easy to establish their pitch, which, in this case, would be three and nine-sixteenths inches from center to center, as represented in Fig. 10.

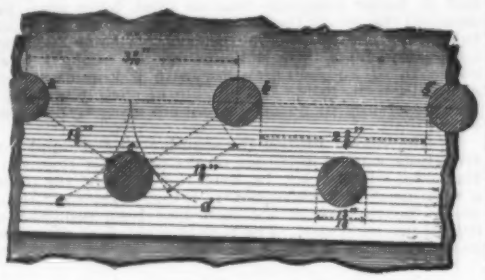


FIG. 10.

It only now remains to establish the position of the rivet hole, *c*, in the adjoining line. This can easily be done by taking a radius, *a e* or *b d*, equal to one-half the distance between the centers of the rivet holes, *a* and *b*, and from them describing two arcs, *p e* and *p d*. If, now, the rivet hole, *c*, be located so as to be tangent to these two arcs, then the spaces between the rivet holes, *a c* and *c b*, will be just equal to that between *a* and *b*. The plates will, therefore, have the same strength in the line *a c b* as in *a b*. The center of the rivet hole, *c*, can be located, perhaps, more easily, by taking half the pitch, *a b*, plus half the diameter of the rivet hole as a radius, and describing from *a* and *b* two arcs intersecting at *c*, which will be the center of the rivet hole.

In the ordinary course of boiler making almost every error of workmanship tends to weaken the plates and give an excess of rivet area, while, in addition, the corrosion, which to a greater or less extent takes place during the life of a boiler, also weakens the plate while scarcely affecting the rivets.

It is for these reasons that I consider that a riveted boiler joint should be laid out so as to have an excess of plate section over that of the rivet.

It is impracticable to proportion the riveted joint so perfectly that the shearing strength of the rivet will be equal to the tearing strength of the plate, for the actual strength of the plates varies more than does the proportion of dimensions of the joint.

(To be continued.)

IRON ORE DEPOSITS.

By R. W. RAYMOND.

THE belief in the eruptive character of iron ore deposits of certain classes held its ground against the newer theories more obstinately, perhaps, than any other part of the old plutonic creed. And the iron ores of Sweden and Norway were the favorites examples of this hypothesis.

A recent report by Prof. A. W. Stelzner, of Freiberg, on the iron ore field of Naeverhaugen, Norway, contains the following paragraphs, which I translate, as showing how completely the former view has been surrendered by competent investigators. Before quoting Prof. Stelzner's remarks, however, I may observe, in passing, that the report in question is a model of fullness, thoroughness and good judgment. The mining field which it discusses presents a series of variable intercalated ore-bearing zones, carrying mixed specular and magnetic iron, and combining occasionally to form bodies of considerable size and purity; while, on the other hand, successful exploitation on a large scale would undoubtedly involve the extraction of much material requiring concentration.

This operation, it is declared, could be cheaply and efficiently performed by jigging, as the ore can be easily separated from the quartz and other minerals of the crystalline schists in which its occurs. No doubt the vast supply of iron ores demanded by modern works must be furnished more and more by mining something besides the pure ores furnished in limited quantities by highly favored mines; and it is interesting to notice the recognition of this fact in a region hitherto famous for its deposits of very rich iron ores.

Concerning the origin of the deposits, Prof. Stelzner says:

"In former years the opinion prevailed in Scandinavia that iron ore deposits of the character described had an eruptive origin. Particularly for Norway this view found in Kjerulf a very warm defender, and it is therefore not surprising that his pupil, Corneliussen, felt bound to ascribe (1877) to the Naeverhaugen iron ores an eruptive origin.

"Nevertheless, this earlier theory has not maintained itself in the progress of time. On the contrary, it has been more and more distinctly and sharply shown that the actually observed conditions can be explained only when in all these *fahlband*-like deposits *sedimentary* formations are recognized—that is to say, beds laid down at the bottom of the former seas, contemporaneously with the material of the schists and limestones which inclose them, but subjected afterward, together with the inclosing rocks, to more or less alteration.

"That this view is the only tenable one as regards the Swedish iron ore deposits was shown first, I believe, in 1859, by M. A. Sjögren; and that the Naeverhaugen occurrence also must be included under it has been argued by Gumaelius (1875), Götting and Vogt.

"For my own part, I am obliged, by all my observations on the spot and in the study of the samples of rock and ore collected, to adopt with profound conviction the theory last mentioned."

Prof. Stelzner does not fail to point out that this question of origin has a direct bearing upon economic value and practical plans of work. For if the deposits are sedimentary and contemporaneous with the country rock, then the common miners' notion of a union in depth to form large masses has no real foundation, and the common advice to sink on this or that unprofitable vein, in the hope of its improvement, must be rejected. He says very wisely, and his words may find wholesome application elsewhere:

"In considering the question of probable development in depth we must rather start from the proposition that our ores were laid down somehow (no matter how) as sediments on a sea bottom—that is to say, as originally more or less horizontal beds. . . . If we distinguish to-day in these *fahlbands*, as in many other tilted layers, the directions of strike and dip, we must always bear in mind that both these two lines were originally horizontal, and that they would have changed *roles* at once if the tilting (which is totally independent of the formation, nature and distribution of the ore) had taken place from the south or north, instead of the east.

"It follows that, for a comparatively undeveloped deposit like this, in the absence of better evidence, it is justifiable to deduce from a study of the outcrops along the *strike* a picture of that which may be expected from openings on the present *dip*. . . .

"It will, therefore, be well to assume that the more or less sudden alternations between rich and poor spots, with which an examination of the outcrops . . . makes us acquainted, will occur also in deeper workings. We must expect that ore bodies rich at the surface will in depth—whether at 10 or 50 or 100 meters—grow poor, and *vice versa*, the uninviting outcrops may become richer in depth.

"That concentrated ore bodies now hidden may here and there be larger and richer than any now exposed, may be conceded as possible; but it is not indicated as specially probable by the exposures made on the surface by prospecting cuts aggregating several kilometers in length."

In a nutshell, the argument is that, for a deposit originally sedimentary and not owing its essential features to any agency subsequent to its tilting, the accidental section made at the surface by natural erosion is as likely to represent fairly the occurrence of ore as any other. This is simply applying the doctrine of probabilities, which, as all mathematicians know, only comes into play as a measure of our ignorance. If developments have been made on a given deposit or in the neighborhood, throwing some light on the distribution of ore in the original bed—as, for instance, that it was not a uniform sheet, but was in bands, determined by currents—then the evidences of the surface must be construed according to this light. But Professor Stelzner has sufficiently guarded his proposition, and, as he states it, it is true.

If it were more generally kept in mind we should, perhaps, hear less frequently the sanguine prophecies of certain "improvements in depth," which have survived in the usage of experts from a time when they had more foundation in theory than can be claimed for them now. As for general experience, they never had any foundation in that.—*Eng. and Min. Journal.*

RECENT CONCEPTIONS OF ARCTURUS.*

By WM. H. KNIGHT.

"IN the whole astonishing history of the human intellect there is no more astonishing chapter than that concerned with the sidereal researches of the last quarter of a century.

"In no other [branch of knowledge] is anticipation so continually outrun by the brilliant significance of the results achieved."—*From the preface to Clerke's "System of the Stars,"* 1890.

In this paper I propose to present one of the latest deductions of science, wherein the sober results of astronomical research seem to have fairly "outrun anticipation."

To avoid encumbering the text with unnecessary detail I shall omit minute fractions where practicable, and shall use approximate round numbers in expressing large distances.

"So far as our present information goes," says Astronomer E. W. Maunder, of the Greenwich Observatory, "Arcturus ranks as the swiftest, the brightest and the largest of all the stars we know." This statement, published in a recent English scientific journal, is the result of facts of a startling nature gathered from observations of this star within the last few years.

Halley was the first to observe in 1718 that the two conspicuous stars, Sirius and Arcturus, were by no means fixed relatively to the stars which seemed to be their neighbors. It was soon found that many other stars, and presumably all of them, were in motion. But their apparent drift across the face of the sky is so small that it can be measured only by astronomical instruments.

This apparent movement of the fixed stars is technically called their proper motion, and in the case of Arcturus it amounts to only 2¼ sec. of arc per annum. It would require about 800 years for Arcturus to cross a portion of the sky equal to the diameter of the full moon; and yet its progress across the sky is more than double that of any other first magnitude star visible in the northern heavens.

The proper motion of Sirius is about half that of Arcturus. The first magnitude star Alpha Centauri, the nearest of the fixed stars, is in the southern hemisphere, and consequently invisible to us. Its proper motion is about 3½ sec. or 50 per cent. greater than that of Arcturus. But there is still a swifter star—a small one of the fifth magnitude in the Swan. It is known as 61 Cygni and is flying along at the rate of 5¼ sec. per annum; and still another, a telescopic star in the Great Bear, with the largest proper motion known, being 7 sec. of arc. Yet this swift wanderer among the stars would require 250 years to cross a region equal to the apparent diameter of the moon.

* Paper read before the Cincinnati Society of Natural History, June 2, 1891.

But it may be asked: Why apply the term swift to movements that appear to be so very inconsiderable? The astronomer takes into view the enormous *distance* of those heavenly bodies, and finds that the figures above given represent tremendous velocities, with which no form of motion known to us on earth is comparable. "As a ship on the horizon," says one writer, "though she may be urging her way swiftly through the water, yet seems at rest, so the distant stars seem unchanging in position, though in reality they travel many miles in every second of time."

Two factors are necessary to determine the actual velocity of a star through space, namely: its proper motion, or *apparent* progress across the sky, and its distance. It is very evident that if two stars have the *same* apparent or proper motion, and one is *twice* as far away as the other, the more *distant* one will move with *twice* the actual velocity of the *nearer* one.

The distance of the stars is determined by their annual parallax, that is, the angle subtended by observing them from opposite points of the earth's orbit in its journey round the sun. Yet, viewed from opposite ends of this great base line of 186,000,000 miles, few of the stars are near enough to produce a measurable angle. All the others are too remote for us to calculate their distance by any methods known to astronomers at the present time.

A parallax of one second of arc would be equal to about $\frac{1}{1296}$ of the breadth of the full moon, and would represent a distance 200,000 times greater than that which separates the earth from the sun, and light, which travels with the unthinkable velocity of 186,000 miles per second, would require 3¼ years to accomplish that distance. Hence that distance, about 20,000,000,000,000 miles, is called 3¼ light years.

The largest parallax yet observed is that of Alpha Centauri, whence we infer that it is our nearest stellar neighbor. Its parallax is about ¾ of a sec., which means a distance of about 4½ light years. This knowledge, taken in connection with its proper motion, enables us to determine its velocity, which is about 16 miles in each second of time. In other words, a star which has a parallax of ¾ sec. of arc and a proper motion of 3½ sec. of arc is moving with a velocity nearly equal to that of the earth (18 miles) in its orbit.

The next star in distance is 61 Cygni, near the head of the Cross in the Milky Way. Its parallax is a little less than half a second, while it has a large proper motion, as already stated, of 5⅛ sec. These elements give this star a distance of 7⅛ light years and a velocity of 36 miles per sec.—much greater than that of any member of our solar system except comets at their perihelion.

The next star in distance, so far as known at present, is Sirius, the brightest of the fixed stars. Its parallax, according to the latest observations, is $\frac{1}{7}$ of a sec., equivalent to a distance of 8 light years, and its proper motion a little more than 1 sec., which gives it a velocity of 9 miles per sec. perpendicularly to or across the line of sight. But a star may have a motion *within* the line of sight, that is, toward or from our system; and here the spectroscope comes to our aid. It shows that Sirius is moving away from us with a velocity of 20 miles per second.

We now come to a very remarkable star. I have mentioned a small star in the northern heavens, called 1830 Groombridge, which has a larger proper motion than any other star, being 7 sec. per annum. Owing to its comparatively rapid motion it has been difficult to measure its annual parallax, and for many years it was fixed at $\frac{1}{10}$ of a sec., which would give the star a distance of 34 light years, and a resulting velocity of 200 miles per second, and it has been called the "Runaway Star." But later observations with more perfect instruments have enlarged the parallax to ¼ of a second, thus reducing its distance to 20 light years and its velocity to 132 miles per second. With that reduced velocity, however, this star would sweep through a space greater than that which separates Cincinnati from Louisville in each second of time.

But our subject is Arcturus, that brilliant star which has been the theme of song and story from time immemorial. It is twice mentioned in that oldest of records, the Book of Job. It was conspicuous in the charts of all the ancient astronomers, from the time of Hipparchus, in the second century B. C., down to the present.

On account of its great brilliancy and large proper motion, an early effort was made to gauge the distance of Arcturus from our system. By the imperfect methods and instruments at first used, its parallax was placed at $\frac{1}{30}$ of a second of arc, or some 33 light years distant. Later astronomers increased this parallax to ⅛ of a second, equivalent to 25 light years, which, taken in connection with its proper motion of 2¼ sec., gave it a velocity of 54 miles per second of time, or about double that of the swift planet Mercury in its orbit.

But within the last two or three years a new and surprising value has been given to the parallax of Arcturus by Dr. Elkin, the astronomer of Yale University. Previous to his work at Yale he had acquired a reputation for painstaking observations and accurate results in the British observatory at the Cape of Good Hope. Equipped with a 7' heliometer provided with the latest improvements, he set himself the task of measuring the parallax of several prominent stars. Devoting himself specially to Arcturus, from no less than 89 observations, taken in connection with 10 comparison stars, he deduced the very small parallax of $\frac{1}{1\,\frac{1}{10}}$ or about $\frac{1}{25}$ of a second of arc, which is equivalent to a distance of 181 light years. This minute parallax (which is assumed to be approximately correct by other astronomers), combined with its large proper motion, gives Arcturus the tremendous velocity of 331 miles per second—a distance 40 miles greater than that which separates Cincinnati from St. Louis. Imagine a body moving from this city to the Mississippi River between the ticks of a clock!

Now, Dr. Elkin admits that there is what is technically called a "probable error" in his observations, but that error is + or —, and would be as liable to make the value of the parallax less than the figure named as to make it more. So that while the velocity of Arcturus *may* be 50 or even 100 miles less per second than computed, it may *possibly* be 50 or 100 miles more.

But until we get new data, based on more extended observations, made with better instruments, we may, in company with the leading astronomers of the world, accept Dr. Elkin's startling figures, and consider Arcturus as 181 light years away, and rushing through space with the unparalleled velocity of 331 miles per second, or about 21 times faster than the earth travels in its orbit around the sun.

Is such a velocity impossible? Is it incredible? Is it unreasonable?

It has been mathematically demonstrated that the velocity with which matter, drawn from distant space, would fall upon the surface of the sun is no less than 383 miles per second, a velocity, it will be seen, almost identical with that of Arcturus.

Many comets which come from interstellar regions and visit our solar system sweep around the sun at perihelion with velocities even higher than that ascribed to Arcturus, and, moving in parabolic curves, again plunge outward into distant space, and passing beyond the dominion of our own sun, enter that of some other mighty star.

Indeed, there is another swift-flying star whose elements, lately determined, imply a velocity but little less than that of Arcturus. I refer to a fifth magnitude star in our northern heavens known as Mu Cassiopeiæ. It has a rapid proper motion of 3·8 sec. of arc, and a recently discovered parallax of $\frac{1}{17}$ of a sec., giving it a distance of 91 light years and a resulting velocity across the line of sight of 244 miles per second of time.

Thus far I have been considering the velocity of Arcturus *perpendicular* to or *across* the line of sight. But we have seen in the case of Sirius that while it is moving with the comparatively low speed of 9 miles *across* the line of sight, it is receding *along* the line of sight with the high velocity of 20 miles per second. How is it with Arcturus? Is he approaching or receding from us? Mr. Huggins again comes to our aid with his spectroscope, and finds that, while Sirius is moving *away* from us at the rate of 20 miles per second, Arcturus is rushing down *upon* us with the far higher velocity of 55 miles per second.

But we need have no fear of a collision. While he will doubtless continue to approach us for tens of thousands of years to come, till he arrives within 140 light years or so, he will then, after a computable period, gradually and then rapidly recede from us and from our part of the sidereal universe, and pursuing an unswerving course, with unabated velocity, he will, in a few million years, pass entirely out of the ken of the most powerful earthly telescope. For, while Arcturus is now approaching us at the rate of 55 miles per second, he is moving athwart our line of vision 381 miles in the same moment of time.

But *part* of that apparent motion of approach on the part of Arcturus is caused by the movement of our *own* sun, which, with its train of attendant worlds, is swinging along through space at the estimated rate of 15 miles per second. Its course is directed toward the constellation Hercules, between Arcturus and the Milky Way.

And now, having obtained some idea, however crude, of the great distance and rapid motions of this remarkable star, we are curious to learn something of his magnitude and physical structure. If he had a visible companion circling around him, as is the case with Sirius, Alpha Centauri, and some other stars which exhibit a measurable parallax, we could weigh his mass, or rather the combined mass of the two bodies, and thence infer his probable magnitude. But Arcturus is a solitary star. No telescope has revealed any attendant companion.

Our only resource, then, is to compare his light-giving power with that of other luminous bodies, and accept such conclusion as may be fairly drawn.

There are three well defined classes of stars, judged by the quality of light they yield. In the first class are the clear white and bluish white stars like Sirius and Vega. These are supposed to be the hottest stars and the most luminous in proportion to the extent of their surface. Then there are the golden yellow or pale orange stars, of which Arcturus and Capella are fine examples. These have begun to cool. Finally, we have the deep orange and red stars like Aldebaran and Antares. These have advanced still further in the cooling process.

Now the spectroscope informs us that our sun belongs to the orange or Arcturus type, and if we could view it from distant space, we should see a lovely star of a pale golden yellow. The question arises, then, how far would our sun have to be removed in order to shine with a brightness no greater than that of Arcturus? According to Mr. Maunder, it would have to be removed to 140,000 times its present distance, or about half the distance between us and Alpha Centauri.

But Arcturus is 11½ million times as far away as the sun, and if our sun were placed at that enormous distance, its diameter would have to be 82 times as great in order to give a light equal to that received from Arcturus. I hesitate to present such figures, implying magnitudes far beyond any to which we have been accustomed, yet they are but logical deductions from observed facts. In other words, upon Mr. Maunder's reasonable assumption, Arcturus must be a gigantic sphere, 550,000 times larger than our sun, with a diameter of seventy million miles, or more than large enough to fill the entire orbit of Mercury.

To make this contrast clearer, let us institute a simple comparison. Jupiter is larger than all the other planets and satellites of the solar system. The sun is a little more than 1,000 times larger than Jupiter. But Arcturus, if our inference is correct, is 550,000 times larger than the sun. By the side of such a majestic orb, our sun, grand and overwhelming as he is in our *own* system, would dwindle to an insignificant star.

Contemplating a world so vast, endowed with such mighty energies, and rushing with such resistless force through the great deeps of space, we cannot resist the questions: Whence came this blazing world? Whither is it bound? What is its mission and destiny? Is it simply a visitor to our sidereal galaxy, rushing furiously through it like a comet? Is it being constantly fed and enlarged by the worlds it encounters and the meteoric matter it gathers up in its wonderful journey? What would be the effect if it chanced to pass through a nebula or a star cluster? Was the new star which suddenly blazed forth in the nebula of Andromeda in 1885 due to a similar cause?

As this mighty aggregation of attractive energies sweeps along his celestial path, thickly bordered with stellar worlds, how many of those worlds will yield forever to his disturbing forces? How many will be swerved from their appointed courses by his irresistible power? How many will plunge into his fiery bosom and be swallowed up as a pebble is swallowed by the ocean?

Are there many great suns like Arcturus, flying on their special missions through space? The late Dr. Croll, in his work on "Stellar Evolution," published two years ago, conjectures that the original constituent bodies of the universe were endowed *ab initio* with high velocities, and that in their swift journeys through space each eventually comes into collision with one of his fellows.

The terrific impact of two bodies moving with a velocity of tens and even hundreds of miles per second transforms the energy of motion into heat, and both worlds are shattered into fragments, melted as in a furnace, and dissipated into luminous gas. And thus a nebula is formed which fills vast regions of space and is ultimately, in the lapse of untold ages, evolved into new systems of worlds.

Sublime as is our theme—a universe of mighty worlds; wonderful as is the complexity of their motions and influences, mysterious as is that power which pervades and rules the whole, more sublime, more wonderful, more mysterious is the human mind, which, from the standpoint of this little world, a mere speck in the great domain of creation, reaches out to the utmost bounds of the universe, formulates its laws, reconstructs its past, forecasts its future, and dauntlessly grapples with the varied problems of atoms and stars, matter and force, time and space, eternity and infinity.

NEW REMEDIES.

To a paper upon new remedies, read at a recent meeting of the Chemists' Assistants' Association (London), by Mr. H. Helbing, the author appends a full list of such remedies (along with their therapeutical use and dose) that will prove very useful to pharmacists and physicians for reference. The list is as follows:

Acetanilide	Analgesic and antipyretic	2-5 grns. per os.
Acetylphenylhydrazin	Antipyretic and analgesic	3-5 grns. "
Agaracine	Antisudorific in phthisis	½ gr. "
Amylene hydrate	Hypnotic, anodyne	½-1 drm. "
Anthrarobin	Against skin diseases	
Antipyrin	Antifebrile and anodyne	15-30 grns. " or subcutaneously.
Aristol	Antiseptic and in skin diseases	
Benzoyl-anilide	Antipyretic	1½-5 grns. per os.
Benzoylguaiacol	Antituberculotic	4-10 grns. "
Betol	Anti-gonorrhoic	In bougie.
Bismuth salicylate	Against gastric affections	6-15 grns. "
Bromoform	Against pertussis	1-2 ms. "
Camphoric acid	Antisudorific in phthisis, etc.	30 grns. "
Cetrarin	Stomachic	2 grns. "
Chloralamide	Hypnotic	30-45 grns. "
Chloralurethan	Hypnotic	15-45 grns. "
Creolin	Antiseptic	5 ms. internally.
Creasote	Anti-tuberculotic	3 ms. per os.
Cresaiol	Antiseptic, antifebrile.	
Ethylenimine hydrochloride	General stimulant	½-¼ grain subcutaneously.
Exalgine	Analgesic	4 grains.
Guaiacol	Anti-tuberculotic	1 m. per os.
Hydrastinine	Against uterine hemorrhage	1 grn. subcutaneously
Hydroxylamine	Against skin diseases	Externally.
Hydracetin	See acetylphenylhydrazine.	
Hypnone	Hypnotic	3-8 ms. per os.
Ichthyol	Anti-rheumatic; against sciatica, erysipelas, skin diseases	Externally and 4-20 ms. per os.
Iodine trichloride	Antiseptic	Externally in 1 p. c. of solution.
Iodoform bituminate	Antiseptic	Externally.
Iodol	Antiseptic	Externally.
Lanoline	As an ointment base or vehicle for other medicaments.	
Mercury phenate	Antisyphilitic	½-¼ grns. subcutan.
Mercury peptogiutine	Antisyphilitic	¼ grn. "
Mercury salicylate	Antisyphilitic	½-¼ grn. "
Mercury succinimate	Antisyphilitic.	
Methacetin	Antipyretic	3 grns. per os. for children.
Methylal	Hypnotic and anæsthetic.	15-30 grns. per os.
Methylene blue	Analgesic	8-15 grns. "
Methylene chloride	Narcotic anæsthetic.	
Monobromacetanilide	Analgesic	1-8 grs. "
Myrtol	Antiseptic in phthisis	5 ms. "
Naphthalene	Antiseptic	2-8 grns. "
Naphtholic acid	Antiseptic and antiparasitic.	
Naphthol	Antiseptic.	
Naphthol camphoratum	Antiseptic antituberculotic	Subcutaneously.
Orexin hydrochloride	Stomachic	5-8 grns. per os.
Paraldehyde	Hypnotic and sedative	15-45 ms. "
Phenacetin	Antipyretic, antineuralgic	8-30 grns. "
Phenylurethan	Antifebrile, antirheumatic	6-8 grns. "
Piperazide hydrochloride	General stimulant	Externally.
Pyoctanin	Antiseptic.	
Pyridine	Antasthmatic	1-1½ drms. by inhalation.
Pyrodin	See acetylphenylhydrazine.	
Resorcin	Antipyretic and anti-fermentative.	
Rubidium ammonium bromide	Antepileptic	½-1½ drms. per os.
Salipyrin	Antifebrile, anti-rheumatic	15 grns. "
Salol	Antiseptic antigonorrhoic	15-30 grns. "
Sodium theobromine salicylate	Diuretic	8-15 grns. "
Sodium anisate	Antipyretic, anti-rheumatic	15 grns. "
Sodium dithiosalicylate	Antipyretic, anti-rheumatic	3 grns. "
Sodium paracresotate	Antipyretic, anti-rheumatic	8-15 grns. "
Somnal	Hypnotic	30 ms. "
Sozoiodol	Antiseptic	Externally.
Sulphaminol	Antiseptic	Externally.
Sulphonal	Hypnotic	15-30 grns. per os.
Terpene hydrate	Against pulmonary affections	3-10 grns. "
Terpinol	Against pulmonary affections	2 ms. "
Tetronal	Hypnotic	15-30 grns. "
Thallin sulphate	Antigonorrhoic	Injection.
Thiol	Ichthyol substitute q. v.	
Tribromphenol	Antiseptic	Externally.
Trional	Hypnotic	15-30 grns. per os.
Thiocresorcin	Antiseptic.	
Urethane	Hypnotic	15-40 grns. "

EFFECTS OF TUBERCULINE ON MONKEYS.

M. HENOCQUE has recently tried the effect of tuberculine on a monkey which presented no symptoms of pulmonary phthisis. Two days after the first injection, according to the *British Medical Journal*, the animal, which had exhibited the characteristic reaction, presented dullness and a few *rales* at the right apex.

After the third injection the dullness was more marked on the right side, and began to be perceptible at the left apex. Soon all the symptoms of acute phthisis manifested themselves, with intense fever, the animal dying ten days after the last injection, after losing a tenth of its weight during that time. The total amount used was six milligrammes of the diluted fluid. On post-mortem examination, four tuberculous nodules of the size of a pea were found in the right lung, and caseous pneumonia involving two-thirds of the organ in the left. In both cases the tuberculous lesions were surrounded by a zone of very intense red hepatization. Pieces of the caseous tissues were injected into two guinea pigs, in one after mixture with sterilized water, in the other with diluted tuberculine. Both animals showed signs of cutaneous and glandular tuberculosis.

THE GENERAL FEATURES OF THE VEGETATION OF LOUISIANA AND ADJOINING REGION, AND ITS PRODUCTS, IN RELATION TO PHARMACY AND ALLIED INDUSTRIES.*

By CHAS. MOHR, Mobile, Ala.

ENTERING upon the warm temperate zone of this part of our common country, with a vegetation in many of its features strange and new to him, the observant visitor from Northern climes beholding them for the first time will not only be struck by their novelty, but will find his attention engaged by the productions of the vegetable kingdom of these lower latitudes in their relation to those of other parts of the globe, and particularly in their bearing upon the activity of man as they contribute to his necessities and comforts.

In response to the call upon the members of our Association, made by the committee on papers to be read before the meeting, to select some subjects presenting local features of interest to members from other localities and of importance to pharmaceutical literature, I have ventured upon the attempt to point out what might be considered of most interest presented by the various phases of the plant world of this subtropical zone, and to direct the attention of our visitors to its products of importance in their bearing on pharmacy and allied branches of industry.

We meet here in the realm of the magnolia, the palmetto, of the long leaved pine, and of oaks, with evergreen or semi-persistent foliage. Favored by a clime of a range of temperature as free from the extremes of withering heat as from the blasts of severe frost, and by an abundant rainfall equally distributed through all seasons, conditions most favorable to the development of arboreal growth, the grand forests, covering yet in this pristine State a large area of the surface, are in their diversity and luxuriance only exceeded by those of the equatorial zone. The trees peculiar to lower latitudes are found here commingling with those that are equally at home in the Northern forests. Palms with short or creeping stems (*Lubel Adansonii, Serenoa serrulata*), their fan shaped leaves wavering under the impulse of the breezes from the Gulf, are growing under the shade of the pine, a tree form most prominent in the forests approaching the subarctic zone; the magnolia occurs side by side with the Northern beech, its dark lustrous foliage standing in pleasing contrast with its Northern associate when attired in its early garb of the softer tints of liveliest green. An arborescent lily (*Yucca aloifolia*), called the Spanish dagger, on account of its spreading, rigid, sharp pointed, lance shaped leaves, shares the ground with American holly (*Ilex opaca*), which also adorns the woodlands of the coasts of New England. Pines of a strictly Southern type contend for the possession of the soil with Northern oaks and hickories.

A similar blending of Southern and Northern plants is found to prevail among the crops of the fields and the garden. By the side of those originally derived from the subtropical zones in the different parts of the globe, producing the great staple products of this section, sugar, cotton, and rice, some of the most important field crops are raised successfully: and in the orchard the pear is found to ripen its fruit with the orange and the Japanese plum (*Eriobotrya Japonica*).

In the following a hasty sketch is attempted of the features that characterize the different regions of this zone as they are traversed in its descent to the Gulf, with a consideration of those products, indigenous to them or cultivated, deemed of most interest to us.

Following the great lines of travel from the North, east of the Mississippi River, the appearance of the magnolia and of the so-called "Spanish moss," a true epiphyte, of the order of Bromeliads (*Tillandsia usneoides*), pendent in long festoons from the limbs and branches of oaks of Southern type, denotes that the warmer temperate zone has been entered (about 33° 30' N. L.) On reaching Louisiana the subtropical forest, distinguished by the prevalence of broad leaved evergreens of various orders, is presented in the fullest display of its characteristic features on the fresher and damper soils of the land rising above the level of the alluvial bottom and the marshes of the coast. The stately magnolia, reaching a height of from 70 to 80 ft., reigns here supreme, forming, with the laurel, water willow, and live oak, the black gum (*Nyssa aquatica*), red bay (*Persea Carolinensis*), the white bay (*Magnolia glauca*), the high forest, a host of trees of smaller size, in great variety, adding to its density; including the American olive or devil wood (*Osmanthus Americanus*), the titi (*Cliftonia ligustrina*), the cyrilla (*C. racemiflora*), the sweet leaf or horse sugar, the yapoon and dahoon (*Ilex Cassine, I. Dahoon*), wax myrtle or bayberry (*Myrica cerifera*), the farkleberry (*Vaccinium arboreum*), the snowdrop tree (*Halesia diptera* and *Bumelia lanuginosa*), all typical forms of this subtropical forest. A number of shrubs, in no less variety, most of them adorned by a profusion of flowers, add to the beauty and interest of these woods. There the interesting American star anise (*Illicium Floridanum*), a calycanthus, rich blooming andromedas, azaleas, blueberries, the gorgeously blooming kalmai, fragrant storax bushes, a stuartia and clethra, unfold their flowers from spring to summer, all intertwined by numerous climbing and twining plants, among them of peculiar interest to us, and most frequent, the yellow jasmine (*Gelsemium sempervirens*), and several species of bamboo briers (*Smilax*) render the dense undergrowth often absolutely impenetrable.

* Paper read before the A. P. A.

THE SOUTHERN PINES.

The highly silicious drift soils of the uplands are chiefly occupied by pines. The genus Pinus is represented in the lower Gulf region by five species: the short leaved pine (*Pinus echinata, P. mitis*) and spruce pine (*P. glabra*), short leaved species with two leaves in the sheath, and the small oval cones with a flat apophysis armed with a weak deciduous prickle, and their wood poor in resinous matter; *P. tæda, P. cubensis*, and *Pinus palustris*, these last three forming a natural group of long leaved species with three, or two and three, leaves in the sheath, gregarious timber trees of large size and highly resinous wood. On account of their resinous products the trees of the latter group merit our closer attention.

The loblolly pine (*Pinus tæda*). In Virginia and North Carolina this tree is found to predominate in damp, sandy soils of the coast region. It forms a considerable part of the forest growth on the tablelands of Alabama and in Northwestern Louisiana, and, almost purely, extensive forests in Western Texas to the limits of the Atlantic forest region. It prefers a damp, cool soil, and in the localities most favorable to its growth reaches a height of from 100 to 110 ft. and a diameter of from 36 to 40 in. As met with ordinarily the wood is coarse, wanting in the strength and durability that distinguish its allies. It yields abundantly a resin rich in volatile oil, and the tree is tapped whenever found within the precincts of the turpentine orchard.

The Cuban pine, slash pine (*Pinus Cubensis*). A West Indian species, most frequent in the flatwoods of peninsular Florida, and in South Carolina, Georgia, and in the Gulf States to Eastern Louisiana, it is confined to the coast plain. It raises its stately trunk to a height of over 100 ft. The wood is heavy, of great strength and durability, highly resinous, the resin richest in volatile oil and of great fluidity. This tree is of rapid growth, attaining the full dimensions of a full sized timber tree within a century.

The long leaved pine, heart or pitch pine (*Pinus palustris Mull., Pinus Australis Michx.*) In economic value this pine takes the first place among the timber trees of the Southern States. The forests of this pine extend over the sandy and gravelly deposit of the Southern drift—the so called pine barrens—without interruption, and cover, in the maritime pine belt of the Gulf States alone, an area estimated at 58,000 square miles, of which 6,400 square miles are located in Louisiana. The tree is provided with an enormous taproot; the tall trunk rises to a height of 90 to, rarely, over 100 ft., with a diameter of from 20 to 35 inches breast high. The massive limbs are contorted, diverging into comparatively few gnarled branches, with their foliage crowded in dense tufts at their extremity, forming an open, irregularly shaped crown. The trunk is found free from limbs for a length varying between 40 and 60 ft. Arrived at the fullness of their growth, trees are from 200 to 250 years old. The leaves are 10 to 16 in. long, obtusely triangular, and arise from the axils of bracts fringed with long white hairs, which, covering them in the bud, impart to the terminal shoots the silvery covering by which this species is distinguished from all others at every stage of its life.

The catkin-like, staminate flowers form dense clusters around the summit of the youngest shoots; the female flowers are united in an oval short stalked catkin, the shapely mucronate carpellary scales being almost totally hidden by their scaly bracts. The flowers appear about the middle of March; the cones mature in the fall of the second year and are of a dull leather color, about 8 in. long, conical in shape when closed, and slightly bent. The seeds are discharged during the latter part of the fall. The wood of this tree is heavy, compact, close grained, and durable, unsurpassed among the pines in strength and elasticity, and is invaluable for heavy constructions. The timber resources of the forests of the long-leaved pine contribute largely to the industrial and commercial wealth of the Southern pine belt. During the year 1889 over 800,000,000 ft., board measure, of lumber have been shipped to foreign and domestic ports from the Gulf States alone.

With us the interest in the tree centers in its resinous exudation, the principal source of the spirits of turpentine and resin entering the markets of the world. According to P. H. Dudley, the wood contains on the average about 18 per cent. resinous matter. Prof. Mayr obtained from the sap wood, rich in volatile oil, 2·65 per cent. of solid resin, and from the resinous heart wood, containing but a small portion of volatile oil, 11 per cent., the wood being absolutely dry.

The crude resin, or turpentine, with the tar and pitch, obtained from the long leaved pine, figured in colonial times as the most important export from North Carolina to the mother country. In the infancy of the naval store industry the distillation of spirits of turpentine was carried on in iron retorts at the ports, the largest part of the crude resin, or turpentine, having been shipped to England. With the introduction of the copper still and its removal to the forest (1834), and the augmenting demand for its products, this industry increased rapidly and soon spread to the pine regions further south.

In traversing the forests of the long leaved pine, the stranger, on his way to the coast, is struck with surprise on beholding the severe injuries inflicted upon the trees by the deep cuts made near their base. These cuts in the body of the tree and the excoriations above them constitute what are called boxes. Ten thousand of such boxes constitute a unit of work, called a crop; trees above medium size, according to their circumference, receive from two to four boxes. These reservoirs for the exuding resin are of the capacity of a quart. The operations in the turpentine orchard begin before the dawn of spring by the laying bare of the ground around the trees and the removal of all loose combustible material from it, which is raked in heaps and burned, in order to prevent the danger of fire during the coming season. As soon as the flow of resin begins, the excoriations are made on the surface of the trunk above the boxes to a height of eight inches, which are gradually increased, by a few incisions repeated every week (chipping), by two to two and one-half inches for every month to the close of the season.

During the first two seasons the boxes are emptied every four weeks (dipping), each dipping yielding on the average from 40 to 50 barrels, of 280 pounds each, crude turpentine. At the end of the season, late in October or November, when the resin ceases to run, the boxes are cleaned from the adhering solidified resin (scraping). For each one of the first two years 70 and 80 barrels respectively of such scrape are obtained, containing but little over half the quantity of the spirits of turpentine yielded by the dip, which amounts to 7 gallons for each barrel. The solid part of the turpentine remaining in the still is the resin of commerce. The dippings of the first two months, the virgin dip, yield this article in highest quality, perfectly clear and almost colorless. The resin resulting from subsequent dips during the first season is of a straw to a pale amber tint, ranking as good quality; and of the second season, of a light brown color, ranking as medium. The product of the crop during the first two years amounts in the aggregate to about 42,000 gallons of spirits of turpentine, and 460 barrels of resin of first to medium quality. In the third and fourth seasons the amount of spirits of turpentine is reduced to 1,000 and 900 gallons respectively, and the resin is of a deeper brown, that of the last year being almost black and of no commercial value. After the fourth year the yield is no longer valuable, and the orchard is therefore abandoned.

The working force of such a plant is generally on 20 such crops, requiring an area of not less than 4,000 acres of pine forest. During the four years of its operation the products amount in the aggregate to about 120,000 gallons of spirits of turpentine and 12,780 barrels of resin of various grades, from which, at the rates of the market prices ruling at present, about $70,000 would be realized. The still in use at such a plant is of a capacity to receive 20 barrels of turpentine at a charge. After having been slightly heated, a constant stream of water from the top of the cooling tank enters the still to the end of the distillation. This process completed, the contents of the still are discharged through a pipe in its bottom, and the liquid resin is strained first through a wire cloth, and then through coarse cotton cloth, before it is transferred to the barrels for shipment.

Repeated attempts to extract the volatile oil from the wood directly have shown that, subjected to distillation by steam at high pressure, it will yield about 3 per cent. spirits of turpentine. From 600 pounds of air dry wood, subjected to the treatment of steam and subsequent destructive distillation, in the apparatus patented by Wm. Messau, 21 pounds spirits of turpentine, 95 pounds pyroligneous acid, 150 pounds tar and oily products, and 127 pounds charcoal have been obtained. In view of such facts, already arrived at ten years ago, it is surprising that this mode of the production of spirits of turpentine has made but little progress, particularly if the immense amount of material serving for this purpose is considered, which, as useless, is left to rot in the woods and is burned up to be gotten rid of at the sites of the sawmills.

A highly profitable disposal of this refuse has of late been found in the manufacture of dead oil. Under this name the oily product resulting from the destructive distillation of the wood of the long leaved pine has, during the past few years, entered the market as a powerful antiseptic, used with decided success in the creosoting of timber. Combined with the by-products obtained in the manufacture of this article, another source of wealth has been added to those already derived from the long leaved pine. The manufacture of pine wool from its leaves is highly promising. It has already passed the experimental stage, and is successfully carried on by a factory in North Carolina in the manufacture of rugs, baling stuff, and similar close fabrics from this material.

Among the fruits cultivated on the uplands, the Scuppernong grape is to be mentioned. The Scuppernong vine is a sport of the Muscadine or Bullac grapevine (*Vitus rotundifolia*), originated in North Carolina, and can only be propagated by layers. The berries, ripening by the end of August, are collected in bunches of about a half dozen; they are of the size of a small plum, and, when fully mature, of a pale amber color. The large amount of acid present in this grape is mostly confined to the cells of the thick hull. The must contains 13 per cent. of sugar. By the separation of the must from the pomace immediately after the berries have been crushed, and by the addition of from one-half to three-fourths of a pound of crushed sugar, an excellent dry wine, of the strength and acidity of a generous Moselle or Rhine wine, can be made.

Descending from the sunny pine hills to the lowlands, the marshes of the coast region are entered upon. They are covered in great part with the forests of the bald cypress (*Taxodium distichum*), which extend also over the submerged depressions throughout the upper part of the delta. The cypress is esteemed for its highly valuable timber. In its dimensions this tree exceeds any other of the Atlantic forests; its mighty shaft rises to a height of 80 to 100 feet above its inflated base, by a diameter of from 4 to 6 feet and over. The sight of these monarchs of the tree world in the gloomy recesses of the primeval forest is almost overwhelming. Surrounded by the peculiar excrescences rising from their roots in the form of bald, sharp cones 2 and 3 feet high above the dark ooze of the swamp, these representatives of one of the most ancient of the gymnospermous types of the arboreal flora of our globe present in their assemblage strangely peculiar features. In these forest-covered swamps the *Tellandsia usneoides*, or moss, is found in great abundance, and the ginning of moss forms one of the industries of New Orleans. After having been gathered the plant is buried in the swamp for ten to twelve months to effect the rotting of its softer tissue. Dried and roughly cleaned, it is shipped to the city, where it undergoes a further cleaning, leaving only the elastic fiber, before it is baled for the market. This moss is largely used in upholstering.

The alluvial lands above the marshes, susceptible of drainage, are of the greatest fertility. Cleared, and protected from overflow by a system of levees lining the Mississippi and its large outlets to the Gulf, they are almost exclusively devoted to the cultivation of the sugar cane. Under the stress of low prices, caused chiefly by the enormous increase in the production of European beet sugar, great efforts have been made of late years in this State in the improvement of the cultivation of the sugar cane, but particularly of the processes in the manufacture of

sugar, with the achievement of splendid results, leading to continued investments in the cultivation of this crop. The rules of thumb and guess have given way to the use of the analytical balance and the polariscope, guided by scientific principles. The investigations of the chemist, instituted by the aid of the United States Department of Agriculture, and at the sugar experiment station of the State, are eagerly taken advantage of by the planter, assisted by mechanical ingenuity and the free expenditure of capital. The extraction of the juice from the cane has been greatly perfected. The amount of saccharine matter left in the bagasse at the mill or in the chip of the diffusion process has been reduced to a minimum; in the first instance by the comminution of the cane by cutting previous to its passing through the rollers. The process of diffusion is steadily gaining favor, and is being more widely employed, as by it the dangers of accidents and consequent delays incident to the employment of heavy machinery under the strain of great power are avoided. Improved methods in the clarification of the juice, and its evaporization effected at low degrees of temperature in the multiple-effect evaporators and the vacuum pan, with the introduction of filter presses, have effected an astonishing increase in the yield of commercial sugar, amounting in some of the best equipped sugar houses to over 100 per cent. of sugar to the ton of cane (mill work at Calumet, Wilkinson's report, 1888-90). The saving effected in manual labor and in the consumption of fuel has kept correspondingly apace with the improvements in other directions. According to the statements kindly furnished by Mr. Murphy, acting president of the Louisiana Sugar and Rice Exchange, in 1889-90, 122,000 acres of cane were ground. Planters with modern apparatus gained 2,753 pounds of sugar; those with apparatus of the old style, 1,847 pounds. The year before 133,000 acres were ground, 2,743 pounds and 2,113 pounds of sugar per acre. In 1890-91 the yield of sugar to the acre has been at least 50 per cent. better, owing to an exceptionally favorable season. The crops for the past six years, in hogsheads, were as follows:

1890.....	..420,000	1887.....	255,185
1889.....	235,448	1886	.148,968
1888.....	267,851	1885.....	231,200

The cultivation of the citrus fruits for profit is in Louisiana confined to the sweet orange (*Citrus aurantium*), and is restricted to the lowest parishes of the delta and of the Gulf coast east of Vermillion Bay. In the parish of Plaquemine, the chief site of the orange orchards, groves from 10 to 200 acres in extent are found, yielding large incomes. The quality of the Louisiana or Creole orange is of the highest order, finding a market at the highest prices. The crop produced in the State is scarcely sufficient to supply the demands of the home market. The lemon (*Citrus limonum*) is raised only in a few sheltered localities on the coast.

The fig produces abundant crops throughout the lower half of the Gulf States. On account of its perishable nature in the damp climate of this region, it is of no value commercially.

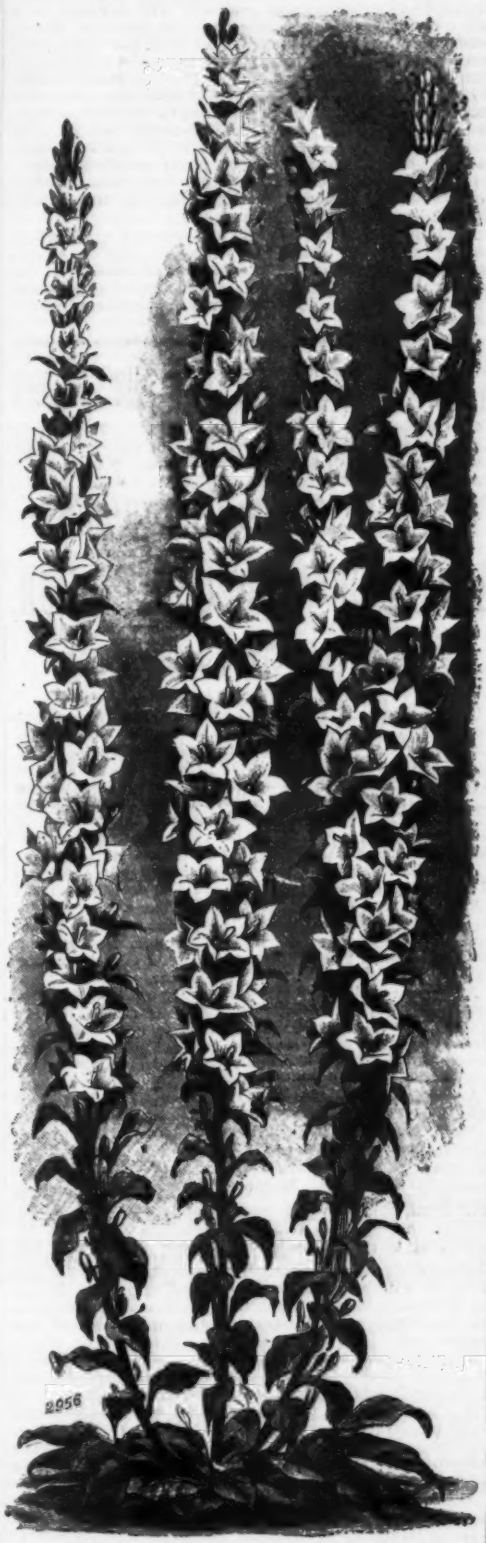
Finally, the ramie plant, or China grass, deserves a short notice. Three species of the urticaceous genus Bohmeria (*B. nivea*, *B. tenacissima*, and *B. candicans*), perennials and natives of the warmer temperate parts of Eastern Asia, have been introduced for their fiber. Louisiana was the first and foremost of the Southern States in the attempts at the cultivation of the ramie, its decortication and the further preparation of its fiber, a short time after its introduction into Mexico (1863). The high hopes entertained on the addition of a new crop to the old staples, the cultivation of which would require far less of the manual labor and attention demanded by the latter, have not yet been realized. Growing with greatest facility, most easily propagated in all parts of the subtropical zone, easy of cultivation, and yielding large crops, an insurmountable obstacle in the way of its general introduction was presented in the want of a machine to perform the decortication of the fiber at a cost low enough to compete with the cheap manual labor of the Orient. During the time of the New Orleans Exposition in 1884 the ramie question met with an active revival. Several large companies have been incorporated under the patents of the inventors of improved machines. From the facts before us it is to be expected that the problems connected with this side of the ramie question are approaching a successful solution. The preparation of the raw fiber to meet the highest requirements of the inventor has already been arrived at.

All that has been said of the ramie applies to another fiber plant, the jute, *Corchorus capsularis* and *C. olitorius*, annuals, also of Asiatic origin. These plants, throughout the subtropical zone, arrive at maturity in fullest perfection, under the easiest cultivation. Many thousands of hundredweights of their crude fiber are imported to this country, required for cotton bagging. With the invention of an improved machine to perfect its decortication, another crop of great importance to the cotton interest will be added to the agricultural resources of this section.

Although of prime importance, the subject of cotton (*Gossypium*) is left out of this sketch as being already familiar to every one present.—*American Druggist.*

PYRAMIDAL BELLFLOWER.

IN presenting a sketch of one of the comparatively large number of admirably grown specimens of Campanula pyramidalis that came under our notice in an Irish garden last summer, the briefest possible reference to this fine bellflower will suffice. To say much in praise of a plant that has occupied a prominent position in English gardens for more than three hundred years would be superfluous, but it must, in passing, be mentioned that while it is eminently attractive in the border, it has no equal among hardy herbaceous plants for the embellishment of the conservatory during the latter part of the summer. When developed in the manner shown in the accompanying illustration, and judiciously arranged with ferns and ornamental leaved plants, the tall spikes of delicate blue flowers present a surprisingly beautiful appearance. The most successful example of the use of this campanula in the decoration of the conservatory that we have seen was met with a few years since in a ducal garden in the North of England, and it deserves special mention for its simplicity. The plants, although not equal to the specimen here figured, evinced cultural skill of a high order, and were placed at intervals of about eighteen inches in an irregular bank of ferns, extending the whole length of the structure. The ferns were just tall enough to hide the pots, and the effect produced by the forest of flower spikes in contrast with the deep hue of the ferns was simply delightful. It is not alone in the conservatory that the pyramidal bellflower is of value. On well-drained soil it can be grown to a high degree of perfection wholly in the open, as proved by the numerous thrifty examples that can at the present time be seen in the gardens of Syon House and elsewhere. The plants are more liable to injury from damp than frost, and on cold wet soils they occasionally suffer severely during the winter, a fact which has induced some cultivators to regard the aid of glass from the end of the autumn until the beginning of the spring as essential to successful practice.



PYRAMIDAL BELLFLOWER, *Campanula pyramidalis.* (Flowers, lavender blue.)

The cultural details are usually dealt with in a manner suggestive of the idea that the production of nicely bloomed examples is a formidable matter. So far from this being the case, it is one of the most simple of the many matters that have to engage the attention of the gardener. There are two methods of raising a stock—one by means of offsets, and the other by seeds; and, although very good results are occasionally obtained by the use of offsets, seedlings are so greatly superior that they should invariably have the preference. The older writers, with few exceptions, recommend the plants being grown on until the third year before they are allowed to bloom, and to admit of this being done the flower spikes are cut off early in the summer of the year following the sowing of the seed. So long a period is not required for the production of the finest specimens, it having been proved that from fifteen to sixteen months is sufficient. The practice of the most successful cultivators is to sow the seed some time between the middle of March and the middle of May, and the second and third weeks of April can be recommended as especially suitable for the commencement of operations. It is desirable that the seed be sown thinly in pans or boxes filled with a light, rich compost and have the assistance of a brisk temperature to insure its germinating quickly. The soil must, as a matter of course, be made moderately firm and quite level on the surface, and it will be an advantage to well water it previous to the seed being sown. In consequence of the susceptibility of the seedlings to injury from damp, the pans should be removed to a cool and airy structure as soon as they are well above the surface. A greenhouse shelf or a position near the glass in an unheated pit or frame will answer admirably, care being taken to water sparingly for a few days after they are removed from the heated structure. Immediately they are sufficiently advanced, prick off into other pans or boxes, keep rather close for a few days, and then gradually harden off and place on a bed of coal ashes on a hard surface in the open. Pot them off separately as soon as they are becoming crowded, and use five inch pots, and a substantial compost. As they are potted place in a position similar to that previously occupied, where they should remain until October. During this period they must be carefully watered, and after the pots are well filled with roots an occasional supply of liquid manure will be beneficial. An unheated pit or frame will afford them the most suitable accommodation during the winter, and throughout the time they are under glass they must have a free circulation of air about them.

Early in March the plants must be shifted into the pots in which they are to bloom, those seven inches in diameter being in some respects preferable. For this shift use a compost consisting of turfy loam, well decomposed cow manure, bone dust and soot, and be careful to pot firmly. As they are shifted place them on a hard surface in the open, and when the roots have reached the outside of the ball, plunge the pots to about two-thirds of their depth in coal ashes. By plunging as here advised the labor of supplying them with water is reduced, and the risk of their suffering from dryness at the roots is practically obviated. From the time the flower spike begins to rise until the flowers are expanding, supply alternately with liquid manure and clean water.

A more simple course of procedure is to plant the seedlings in a reserve bed, when they are transferred from the boxes into which they are put when pricked off, and leave them undisturbed until the spring following. To insure success the bed must be well drained and thoroughly prepared, and the seedlings should be put eight or nine inches apart each way. Toward the end of March or early in April they can be lifted and potted up, and if this is carefully done they will not suffer to an appreciable extent. For lifted plants eight inch pots will be required, as when put in the size advised for those grown in pots from the first they frequently flag during the periods of bright sunny weather. Those intended for the flower garden should be grown in a reserve bed until the spring following the sowing of the seed, when they should be transferred to their permanent quarters, care being taken to lift them with a good ball of soil.

It may be added that the white variety is not so vigorous as the typical form, the flower spikes of well grown specimens usually rising to a height of four or five feet.—*The Gardeners' Magazine.*

FERTILIZER ANALYSIS.

WE give the following, as instancing the methods adopted by the Massachusetts Agricultural Society.

Preparation of Sample.—The entire available sample is spread upon a smooth, hard surface, and intimately mixed without grinding, all lumps being broken up with a spatula. Unnecessary loss or gain of moisture is to be avoided. Moisture: dry 2 grms. in the air bath at 100° to 110° C. to a constant weight.

I. *Total Phosphoric Acid.*—Weigh out 2 grms. in a platinum crucible, and destroy the organic matter by carefully burning in a muffle. Weigh when cool to determine the "organic and volatile matter." Digest the crucible and contents with dilute hydrochloric acid until the solution of the latter is complete. The "insoluble matter" on the filter is burned and weighed. The residue left from the evaporation is taken up with dilute nitric acid, if the molybdic method is to be followed, but with hydrochloric acid if method 2 is preferred. The solution after filtering is made up to a volume of 200 cubic centimeters with distilled water.

1. The molybdic method: 25 cubic centimeters of the solution are digested in a water bath at 65° C. from one to two hours, with an excess of molybdic solution. The precipitate is brought upon a filter, and washed with water containing a little molybdic solution. It is then dissolved in ammonia water, the solution nearly neutralized with hydrochloric acid, and magnesia mixture added slowly, with constant stirring. The precipitate is allowed to stand at least three hours, when it is filtered through a Gooch crucible, washed with dilute ammonia, ignited and weighed.

2. The following method is occasionally employed when phosphates of iron and alumina are present in small quantities only: To 50 cubic centimeters of the hydrochloric acid solution add ammonia in slight excess. After standing a few minutes, acidify with acetic acid, and filter off the phosphates of iron and alumina, washing carefully with water. To the filtrate add sufficient oxalate of ammonia to precipitate all the lime; digest for several hours at a temperature below boiling, and filter through double filters which have previously been washed with oxalate of ammonia, washing thoroughly with water. Dissolve the phosphates of iron and alumina on the filter with warm dilute hydrochloric acid, and wash into a beaker containing a small quantity of powdered tartaric acid. When the latter has gone into solution, mix with the filtrate from the oxalate of ammonia. The phosphoric acid is precipitated with magnesia mixture, and treated as in 1.

Soluble Phosphoric Acid.—Weigh out 2 grms. into a beaker, cover with 10 to 15 cubic centimeters of water,

and allow it to stand for fifteen minutes, stirring three times at equal intervals. Decant the solution through a filter into a graduated cylinder. Add another like quantity of water, and let it stand fifteen minutes more, stirring as before. Filter the solution into the cylinder, and wash the residue on the filter until the filtrate amounts to 200 cubic centimeters. The phosphoric acid is determined in an aliquot part of the solution as under total phosphoric acid.

Insoluble phosphoric acid: Add 100 cubic centimeters of neutral ammonium citrate (sp. gr. 1·09) to the beaker in which the digestion with water has been made. Put in a water bath and heat to 65° C. Drop in the filter containing the residue from the above operation, and digest for thirty minutes, stirring every five minutes. Filter and wash thoroughly, using the suction pump. Dry and burn. The ash is then treated as under total phosphoric acid.

Reverted phosphoric acid: The sum of the soluble and insoluble subtracted from the total gives the reverted or citrate soluble phosphoric acid.

Reagents: The reagents used in the estimation of phosphoric acid are prepared according to directions given in the "Proceedings of the Association of Official Agricultural Chemists," 1889, pages 225 and 226.

For ammonium citrate, 370 grms. of citric acid are dissolved in 1,500 cubic centimeters of water, nearly neutralized with crushed carbonate of ammonia, heated to expel carbonic acid, exactly neutralized with ammonia, and brought to a specific gravity of 1·09.

The molybdic solution is prepared by dissolving 100 grms. of molybdic acid in 417 cubic centimeters of ammonium hydrate of specific gravity 0·96. Pour this solution into 1,250 cubic centimeters of nitric acid of specific gravity 1·20, and set in a warm place for several days, or until a portion heated to 40° C. deposits no yellow precipitate.

The magnesia mixture is prepared by dissolving 110 grms. of crystallized magnesium chloride and 280 grms. of ammonia chloride in 700 cubic centimeters of ammonia of specific gravity 0·96, and bringing to a volume of two liters.

2. *Methods of Determining Nitrogen.*—The Kjeldahl and soda-lime methods recommended by the Association of Official Agricultural Chemists, in their "Proceedings," 1889, pages 218 to 221, are employed, with occasional control analyses by the absolute cupric oxide mode.

3. *Method for Determining Potash.*—Weigh out two grms. of the material in a platinum crucible, char thoroughly at a temperature just below red heat. Digest for several hours with very dilute hydrochloric acid on the water bath. Filter into a graduated cylinder, and make up to 200 cubic centimeters. Take 50 cubic centimeters for each test. Warm and add, in small quantities at a time, an excess of barium hydrate. Digest for one or two hours at a temperature of 70° to 90° C., filter, washing carefully, and add to the filtrate a few drops of ammonium hydrate, and enough ammonium carbonate to precipitate the excess of barium hydrate. Filter and bring the filtrate to dryness on the water bath in a platinum dish. Heat carefully in the covered platinum dish at a temperature just below red heat, until compounds of ammonia cease to come off. Take up the residue in water, filtering if necessary, and add an excess of platinum tetrachloride. Evaporate to dryness on the water bath, add a small quantity of 80 per cent. alcohol and allow it to stand for a few hours. Filter through a Gooch crucible, washing with alcohol, dry and weigh, or filter through paper, wash as before, dry and brush the potassium platinic chloride upon a weighed watch glass with a camel's hair brush, and weigh. If very impure, the double salt is washed with the strong solution of ammonium chloride, saturated with potassium platinic chloride.—*Massachusetts Agricultural Report.*

MANGANESE IN IRON AND STEEL.

By L. BLUM.

L. RURUP recently made known (*Chemiker Zeitung*) a method for the determination of manganese in iron and steel, said to be a modification of the Volhard process, calculated to economize time.

Six grms. of the material are weighed out, placed in a liter flask, after being dissolved and oxidized, neutralized, mixed with sodium sulphate, filled up to the mark, and filtered through two folded filters. Of the filtrate 500 c. c. are placed in a one-liter Erlenmeyer flask, mixed with zinc oxide, heated, and tritrated with permanganate.

In an editorial remark in the *Chemiker Zeitung*, attention is called to the differences which arise from neglecting the volume of the precipitate of basic ferric sulphate. The author now points out two other defects in the method calculated to affect the accuracy of the results.

According to Volhard, the exact conversion of a manganous salt into a hydrated manganese peroxide by the action of permanganate ensues only if another strongly basic oxide is present in solution. For this purpose he found zinc oxide the most suitable. Meinecke further showed that considerable quantities of zinc sulphate—25 to 30 grms.—must be present in order to effect the intended purpose. As in Rurup's modification its presence is excluded, the precipitate formed on titration will always contain manganous compounds, thus rendering the consumption of permanganate too small.

A further defect, which tells in the same direction, lies in the presence of free zinc oxide. On this point Meinecke has made careful investigations, and has ascertained that a deficient consumption of permanganate, and consequently reduced result, is in direct connection with the presence of undissolved zinc oxide.

These facts speak decisively against the adoption of Rurup's modification, especially as in Volhard's method, as used in metallurgical laboratories, a determination of manganese can be conveniently completed in three-quarters to one hour.—*Zeit. Anal. Chemie; Chem. News.*

THE PURITY OF BENZENE.

By C. LIEBERMANN and A. SERGEWETZ.

THE occurrence of carbon bisulphide in crude benzene is well known. The authors point out that most of the commercial pure benzene, boiling at 80-82°, contains this substance, the presence of which can be readily detected by means of phenylhydrazine. On the addition of this reagent to a small quantity of the benzene, phenylhydrazine phenylsulphocarbazide,

$$CS\begin{matrix}<S.\,N_2H_3C_6H_5\\ N_2H_3C_6H_5\end{matrix}$$

which melts at 97°, separates out after a short time.

The presence of carbon bisulphide in so-called pure benzene may sometimes lead, in working with certain substances, to very annoying secondary reactions. The average percentage of CS_2 in such benzene was calculated by the authors, from the weight of sulphocarbazide formed, to be 0·2 to 0·3.

The testing of benzene can easily be carried out, and quantitative results obtained, by treating 10 c. c. benzene with 4–5 drops of benzene, and shaking vigorously at intervals during an hour or an hour and a half. When 0·2 per cent. of CS_2 is present, the precipitate appears quite voluminous, and with 0·06 per cent. it is still quite easily perceptible; but the limit of the reaction appears to be reached at 0·02 per cent. (0·17 grm. in a liter), and it is necessary to start the crystallization by adding a crystal of the sulphocarbazide. By submitting the benzene to a distillation, and testing the first portion of the distillate, the examination can be pushed still further. This notice will perhaps be sufficient to cause greater care to be taken in separating the first runnings of the purer qualities of benzene. "Crystallized" benzene has been found by the authors to be always free from carbon bisulphide, with the exception of one sample.

Phenylhydrazine is capable of extended application for the purpose of estimating carbon bisulphide in this manner. The authors, for example, succeeded in detecting this impurity in a sample of thiophene prepared by Volhard's method, which was otherwise pure.—*Chem. Zeit.*

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